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Objective cost estimates for planning and operating systems should be made after an assessment of administrative factors (school environment) and instructional factors (learning objectives, type of presentation). Specification of appropriate sensory stimuli and the design of alternative systems also precede cost estimations for production, distribution, and reception. Researchers define a hypothetical educational task as a basis for cost comparison of alternative systems, excluding computer-assisted instruction (CAI) from assessment charts. Cost-saving considerations modify the utilization and technology of media systems and the organization of educational systems. An appendix to Volume I presents methodology for estimating costs, a summary of CAI applications and expenses, and educational environment models. (TI)

ED0 24273

COST STUDY OF EDUCATIONAL MEDIA SYSTEMS AND THEIR EQUIPMENT COMPONENTS

Volume I

Guidelines For Determining Costs of Media Systems

Final report • Contract OEC 1-7-079006-5139 • May 1968
U.S. Department of Health, Education and Welfare
Office of Education
Bureau of Research

GENERAL LEARNING CORPORATION • EDUCATIONAL SERVICES DIVISION

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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FINAL REPORT

Contract No. OEC-1-7-079006-5139

COST STUDY OF EDUCATIONAL MEDIA SYSTEMS AND THEIR EQUIPMENT COMPONENTS

Volume I
Guidelines for Determining Costs of Media Systems

GENERAL LEARNING CORPORATION
EDUCATIONAL SERVICES DIVISION
5454 Wisconsin Avenue
Washington, D. C. 20015

May 1968

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U. S. DEPARTMENT OF
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INTRODUCTION

In view of the national goal to provide every citizen the opportunity for quality education to the level of his desire and ability, the educator is confronted with the task of providing each student with the best education possible within the bounds of available funds, personnel, and facilities. Educational media systems may be a valuable source of help in the accomplishment of this task. Because of the lack of sufficient data, the selection of the best medium for presentation of a particular instructional unit is usually based on a subjective evaluation of effectiveness and a superficial estimate of cost.

The purpose of this study was to investigate the cost of instructional media systems. The first objective was to provide the educator with a set of guidelines for realistically estimating the total cost of such systems. To gain this objective it was necessary first to identify and investigate a set of commonly used or proposed media systems and to develop a methodology for determining total system costs.

The data collected and analyzed during the study achieved the second objective of providing a data base for use by researchers in further studies relating to the selection, implementation, and operation of instructional media systems. A final objective of the study was to present recommendations which can result in cost savings when media systems are used. These recommendations are in the areas of media utilization, application of new technology, and educational system organization.

The results of this study are reported in three volumes. This first volume provides the educator with a set of guidelines for deriving the total cost of planning, implementing, and operating an instructional media system. It also includes a summary of cost comparisons of several types of systems designed to perform the same hypothetical instructional task as well as a summary and discussion of cost-saving recommendations.

Volume II consists of the technical material and data on which the above two summaries are based, and Volume III is a report on computer assisted instruction.

SUMMARY OF VOLUME I

The educator interested in exploring the cost and feasibility of using particular instructional media systems has had few sources from which to solicit unbiased advice. Volume I provides a set of general guidelines for determining objective and realistic cost estimates for planning, implementing, and operating media systems. In addition, it provides a summary of cost comparisons of various media systems and a summary of cost-saving considerations.

In order to relate the media system to its educational setting and establish a frame of reference for the data in this report, the entire process of media selection is reviewed briefly. The process begins with an examination of the educational setting in terms of selected administrative and instructional factors. On the basis of this examination, learning objectives are specified and alternative media systems are designed. Only then are cost estimates made for the various alternatives. Cost estimation is followed by an appraisal of the alternatives and, finally, the appropriate system is selected. The steps after selection include the customary sequence of bids, contracts, and installation, followed by implementation (training and operation) and evaluation.

The section on general cost determination helps the educator to relate the media system categories of production, distribution, and reception (in terms of capital and operating costs) to the variables that exist in his particular educational setting.

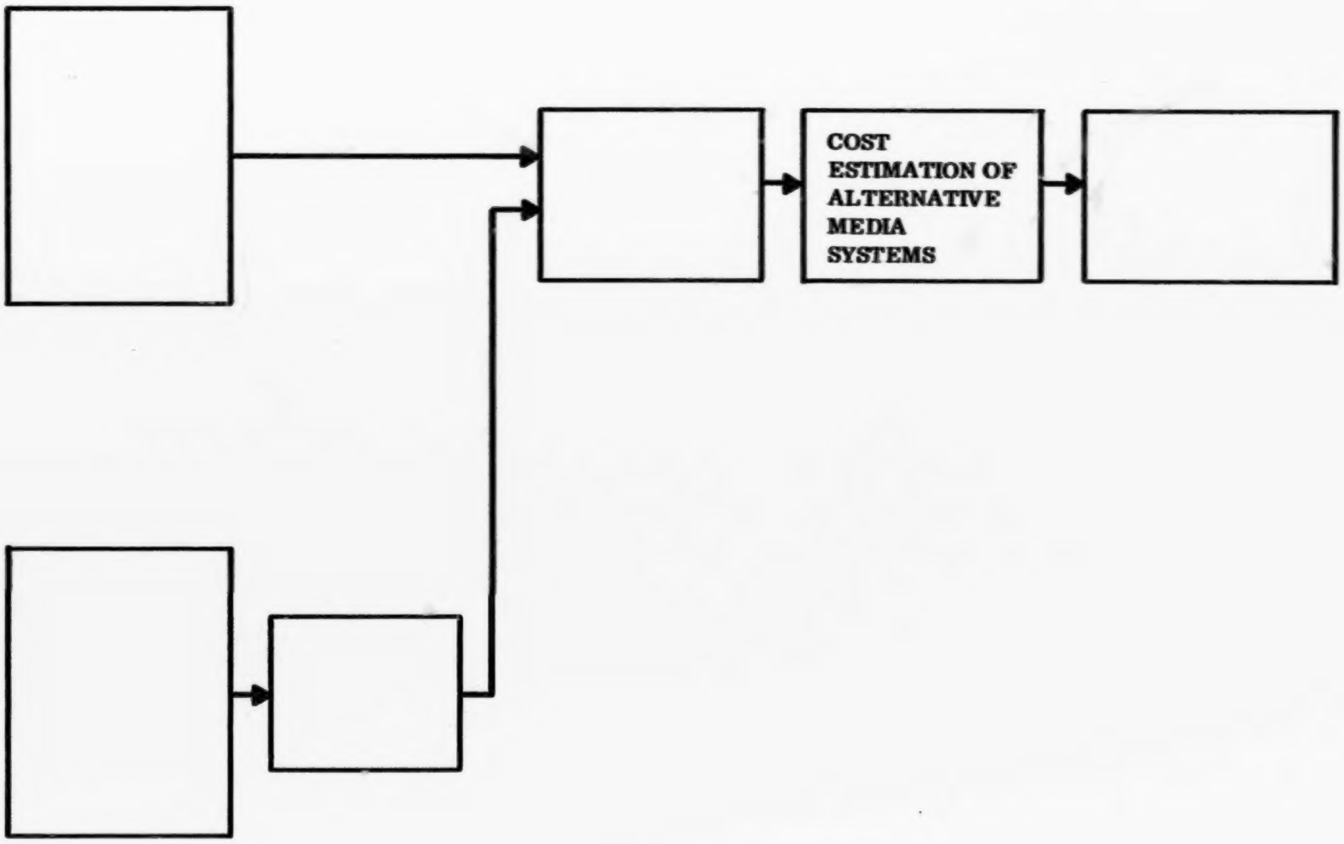
The general assessment of media systems presented in the cost comparison section provides a useful tool for screening systems in terms of their suitability to a particular educational environment. This is but a preliminary screening, however, since final cost comparison must be based upon the broader considerations of the educational task which the media system is designed to perform.

The summary of cost-saving considerations discusses the recommendations and implications that have been drawn from Volume II of this study, the Technical Report. It outlines three major areas where changes can result in cost savings when media systems are utilized in the educational environment. These areas are the utilization of media systems, the technology of media systems, and the organization of educational systems.

Included at the end of this volume are a Glossary, References, and an Appendix consisting of three sections: Methodology for Estimating Costs, Computer Assisted Instruction — A Summary, and Educational Environments.

SELECTION OF A MEDIA SYSTEM — AN OVERVIEW

Estimating the costs of purchasing, installing, implementing, and operating a media system is not an isolated activity. Rather, it is part of the broader overall process of media system selection as illustrated in the following diagram.



Cost estimation, the subject of this study, must be preceded — and followed — by certain other necessary activities (the untitled boxes) to insure optimum results from the use of a media system. These activities, while outside the scope of this study, are examined briefly here to show their relation to cost estimation.

The major steps in media system selection appear graphically in the diagram on the following page. Although the component activities are presented and discussed sequentially, it should be emphasized that the steps in media selection are interactive. The results of an activity or activities in one step may not only provide data for a subsequent activity, but may also modify activities that have gone before.

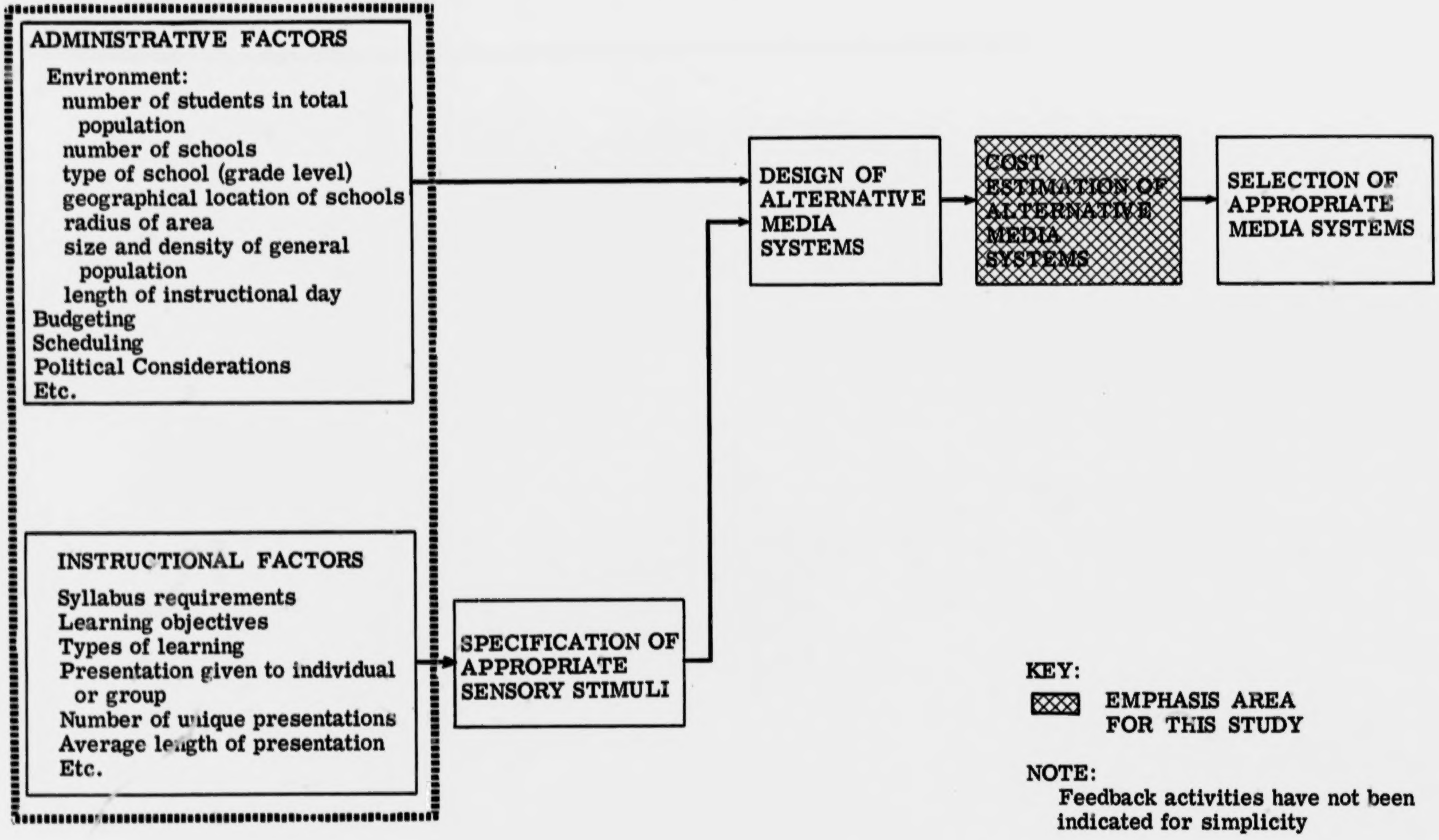

ADMINISTRATIVE FACTORS
Environment:
number of students in total population
number of schools
type of school (grade level)
geographical location of schools
radius of area
size and density of general population
length of instructional day
Budgeting
Scheduling
Political Considerations
Etc.
INSTRUCTIONAL FACTORS
Syllabus requirements
Learning objectives
Types of learning
Presentation given to individual or group
Number of unique presentations
Average length of presentation
Etc.
SPECIFICATION OF APPROPRIATE SENSORY STIMULI
DESIGN OF ALTERNATIVE MEDIA SYSTEMS
COST ESTIMATION OF ALTERNATIVE MEDIA SYSTEMS
SELECTION OF APPROPRIATE MEDIA SYSTEMS
KEY:
EMPHASIS AREA FOR THIS STUDY
NOTE:
Feedback activities have not been indicated for simplicity

Figure 1. Selection of a Media System - An Overview

The selection process begins with an examination of the educational setting in which the chosen media system is to function. Most educators agree that this setting consists mainly of an administrative component and an instructional component. Each component contains limiting factors which shape the specific data used in later stages of the selection process, namely, specification of appropriate sensory stimuli, design of alternative media systems, cost estimation of the alternative systems, and, ultimately, selection of the appropriate system.

Only those components and factors deemed pertinent to the media selection process are included here. Neither the designation of components nor the list of factors should be taken to be exhaustive or inflexible. Even the grouping of factors is conditional since some could appropriately be considered a part of either component. In short, there is considerable overlap as well as a pattern of strong interrelationships among factors in both components.

Administrative Factors

The factors classified as administrative are those existent in the nature of the school, its geographic location, political milieu, and imposed legal requirements. Following are examples of the effect such factors can have on media selection.

1. The number of students assigned to the educational unit being studied (one school, a school district, several districts) will influence the size of the media system required.

2. The topographical features of the environment will influence consideration of media systems requiring "line-of-sight" transmission.

3. The relationship among political units can either restrict or enhance the cooperation of educational units in an effort to achieve more efficient utilization of a media system.

Scheduling is an administrative factor that is closely linked to instructional factors. The combination of individual and group activities determined by the learning objectives will influence the master scheduling of resources and student assignments. On the other hand, scheduling of students, teachers, and facilities to optimum advantage may modify the extent to which a combination of individual and group activities can be used.

The type of school for which a media system is sought will have a substantial effect on final system selection. Schools of different grade level ranges, with their different curriculum needs, cannot employ the same media mix with equal effectiveness for instructional purposes.

The data that emerges from an examination of administrative factors are essential to the design of a media system which meets the requirements of the educational setting. But such data have value only as they are modified by the instructional factors.

Instructional Factors

Curriculum development practices provide equally important data to the design of a media system for a unique educational setting.

An ideal way to develop curriculum, one that would provide the most useful basis on which to select media, begins with general decisions and progresses to the more specific.

1. Establish general educational goals: What are the purposes to be achieved by education?

2. Specify terminal behavioral objectives: What will a person who has achieved the educational goals be able to do?

3. Specify the interim objectives: What knowledge and skills are needed to perform the terminal objectives?

4. Identify the types of learning: What activities and experiences are needed to learn such knowledge and skills?

5. Determine need for individual and group instruction: Is learning best achieved on an individual basis or in a group? (The answer may result in a combination of individual and group activities. However, the ratio of one to the other may be modified by existing facilities, basic philosophy, and other factors. For example, some school buildings with traditionally designed classrooms cannot accommodate varieties of group sizes and activities.)

This precise approach to curriculum development is too complex to be treated fully here. More detailed discussions of these development techniques may be found in the references on page 31 .

Specify Appropriate Sensory Stimuli

Information drawn from the examination of the stated interim objectives and the defined types of learning will provide answers to questions of critical importance in media selection.

1. Does this knowledge or skill require identification or discrimination of sounds?
2. Are color, motion, or touch essential to successful learning?
3. What medium best provides these characteristics? Are there other media with the same capability?
4. Is this a group or individual learning activity? Which medium is most appropriate?

Design Alternative Media Systems

The required characteristics of media, together with data from the instructional and administrative components, shape the design of alternative media systems.

At this stage, a professional media systems designer should be consulted. Armed with his own expert technical knowledge and the specific data from the educational setting, he can design two or three alternative systems especially tailored to the particular needs of the setting. The more precise and comprehensive the data, the better the design.

In some ways the design of alternative systems is analogous to an architect designing a house. Given a maximum cost and minimum number of rooms, the architect can produce a variety of designs that may or may not be acceptable. Given added information such as the activities of a family, preferences in architectural style, tastes in furniture and decoration, and the ages of the children, the architect is more likely to produce designs that come close to fulfilling the expectations and needs of his clients.

It should be noted that the alternative media systems which result at this point in the media selection process will probably be a combination of several different media (television, audiovisual, radio). No single medium has all the characteristics and capabilities required by the learning objectives of a particular educational setting.

For further discussion of design considerations from the viewpoint of the media system designer, see Section A of the Appendix.

Estimate Cost

The costs of the alternative media systems, designed in the preceding step, can now be estimated. Since the results of the investigation of this step are the substance of this report, cost estimation is mentioned here only to maintain the sequential review of the overall selection process. The next section of this volume, Cost Determinations, discusses some general considerations that are necessary when estimating costs of media systems. The specifics of the methodology used in estimating costs can be found in Section A of the Appendix.

Select Appropriate Media System

The results of the design and cost estimation activities provide the basis for the final selection of the media system best suited to the needs and limitations of the particular educational setting.

A review and comparison of the costs, capabilities, and limitations of the alternative systems may require a reconsideration of decisions made earlier. Perhaps the utility of one system, though exceeding budget limits, may be sufficient to cause a reallocation of funds; or, perhaps, the cost of each of the alternatives is so great as to require a modification of objectives or an alteration of other factors in the educational setting. This process of reviewing, adjusting, redesigning, and reestimating may have to be repeated several times before a final selection is made.

Through this refining process, the final media selection will be made after all known factors are weighed and the best compromise is achieved. The effectiveness of a particular medium, however, remains largely a professional judgment. At this time there are few evaluation techniques available to show the superiority of one medium over another in achieving the stated instructional objectives.

Steps After Selection

Final selection of a media system is followed by the customary procedures of contract specification, review of bids, and award of a contract for equipment and installation. Two other "post selection" activities are essential at this point — implementation (training and operation) and evaluation. Logically, planning for these activities should be completed well before this time. Some of the groundwork should already have been laid at earlier stages of the selection process. Staff acceptance of new media is more likely if teachers have participated in the selection process and have received instruction in how the new media are to be used. Operating procedures which allow for a period of adjustment must be carefully planned and introduced.

The operational media system should be evaluated in terms of all the factors involved in the selection and implementation process and should be measured against the criteria on which each decision was based. For example:

1. Administrative Factors
    a. How do actual costs (capital and operation) compare with estimated costs?

b. Do the number of students using the system — and the number of hours it is used — equal, exceed, or fall short of estimates?

2. Instructional Factors

   a. How does actual learning achievement compare with the specified objectives?
   b. Are the media selected appropriate to the specified sensory stimuli? (It is difficult — if not impossible — in this area, to separate the effect of the medium from the effect of the material presented via the medium.)

3. Other Factors

   a. Are the teachers using the media? Are they using it to best advantage?
   b. Were the plans for scheduling, implementation, and operation adequate?
   c. What is the student reaction (aside from learning achievement)?

COST DETERMINATIONS

Production, distribution, and reception are the three generally accepted divisions into which each media system can be separated for purposes of cost estimation.

Production

Production covers the creation or acquisition of lessons, programs, etc., in the form to be presented by the media system. The scope (and, therefore, the cost) of production activities is a function of the number of lessons or other instructional units that must be produced in a defined period of time. Factors that enter into the scope of the production activity include

- average length of instructional unit,
- type of program (lecture, drama, demonstration, etc.),
- quality of production, and
- physical form of a particular medium.

Once the scope of the production activity has been determined, detailed production requirements can be formulated. By examining each of these requirements relative to the chosen media system, a rough estimate of system cost can be determined. The final cost estimate is produced by breaking down each of these requirements into identifiable units — cameras, projectors, teachers, equipment operators, raw tape stock, etc. — and assigning actual costs to each unit.

The following list is a sample breakdown of production requirements divided into capital and operating costs; the overall cost may not be as significant as the ratio of capital to operating cost or the operating cost alone. This list cannot be defined further until a specific system has been selected. (For discussion of specific systems see Appendix, Section A.)

Capital Costs

Initial planning
Equipment
Facility
Initial software
Initial teacher training
Initial operator training
Test equipment
Expansion capability

Operating Costs

Operating personnel
Maintenance personnel
Teacher training
Operating personnel training
Administration
Equipment maintenance
Replacement spare parts
Facility upkeep
Consumable supplies
Related materials
Current programming
Program update
Research, testing, and evaluation

Distribution

The main variables in distribution are the number of channels required to have students receive material at the proper time and the number of central points at which this material can be placed in the distribution channels. The number of channels can be determined once the media programs are scheduled and any conflicts in the schedule have been eliminated. The number of central distribution points is determined by the type of media system employed and the environment within which it is to operate.

For example, if the schedule indicates that on a given day between 9 a.m. and 9:30 a.m. the media system must provide a ninth grade lesson in history, an eighth grade lesson in mathematics, and a seventh grade lesson in science, three channels would be needed to provide this service simultaneously. Thus, if a closed circuit television (CCTV) system is being used, three television channels would be required.

The number of central distribution points for a closed circuit television system would equal the number of program input stations which in turn would depend upon the geography of the environment and the location of population centers.

Once decisions have been made on these variables, a rough system configuration can be made and estimates of cost attempted by breaking down the distribution function according to the following list.

Capital Costs

Initial planning
Equipment
Facility
Initial operator training
Test equipment
Expansion capability

Operating Costs

Operating personnel
Maintenance personnel
Operating personnel training
Administration
Equipment maintenance
Replacement spare parts
Facility upkeep
Consumable supplies
Related materials

Reception

The number of reception points, which can be calculated on a per school basis, is a function of the schedule, the size of the group, and the characteristics of the media system. The number of reception points for a television system is the number of television sets; the number of reception points for a language laboratory is the number of headphones, etc.

Assuming a particular schedule configuration, let us examine the requirement for television sets. The average length of a program affects the cost of producing it to a greater extent than the cost of receiving it. Whether a program is ten minutes or one hour long, the television set and the class usually remain in the same room for the entire session. The set cannot be used by a different class or for a different program during this period. Thus, the minimum number of receivers per school is determined by the maximum number of unique programs transmitted per hour and the number of groups watching each program. If, during one particular hour of the week, Math I is transmitted to three groups and English II is transmitted to four additional groups, then seven receivers are needed to receive the programs.

The reception category can be broken down into the following areas for cost estimation purposes.

Capital Costs

Initial planning
Equipment
Initial teacher training

Operating Costs

Teacher training
Administration
Equipment maintenance
Consumable supplies
Related materials
Research, testing, and evaluation

Summary

These are only some of the preliminary considerations necessary to determine the costs of production, distribution, and reception of a media system. More detailed analysis requires identification of the educational task and the specific media system. Detailed procedures for estimating the costs of the specific systems covered in this report can be found in the Appendix, Section A.

The diagram on the following page illustrates the sequence of general steps taken to determine the cost of a media system. Blocks 1 and 2 produce the media system characteristics which determine the system's configuration. Blocks 3, 4, and 5 develop the costs in each of the three divisions into which the system has been separated. Block 6 sums up all costs prior to the selection decision that is made in Block 7. Actually, decisions are made throughout the entire process and some systems may be rejected or modified well before Block 7 is reached.

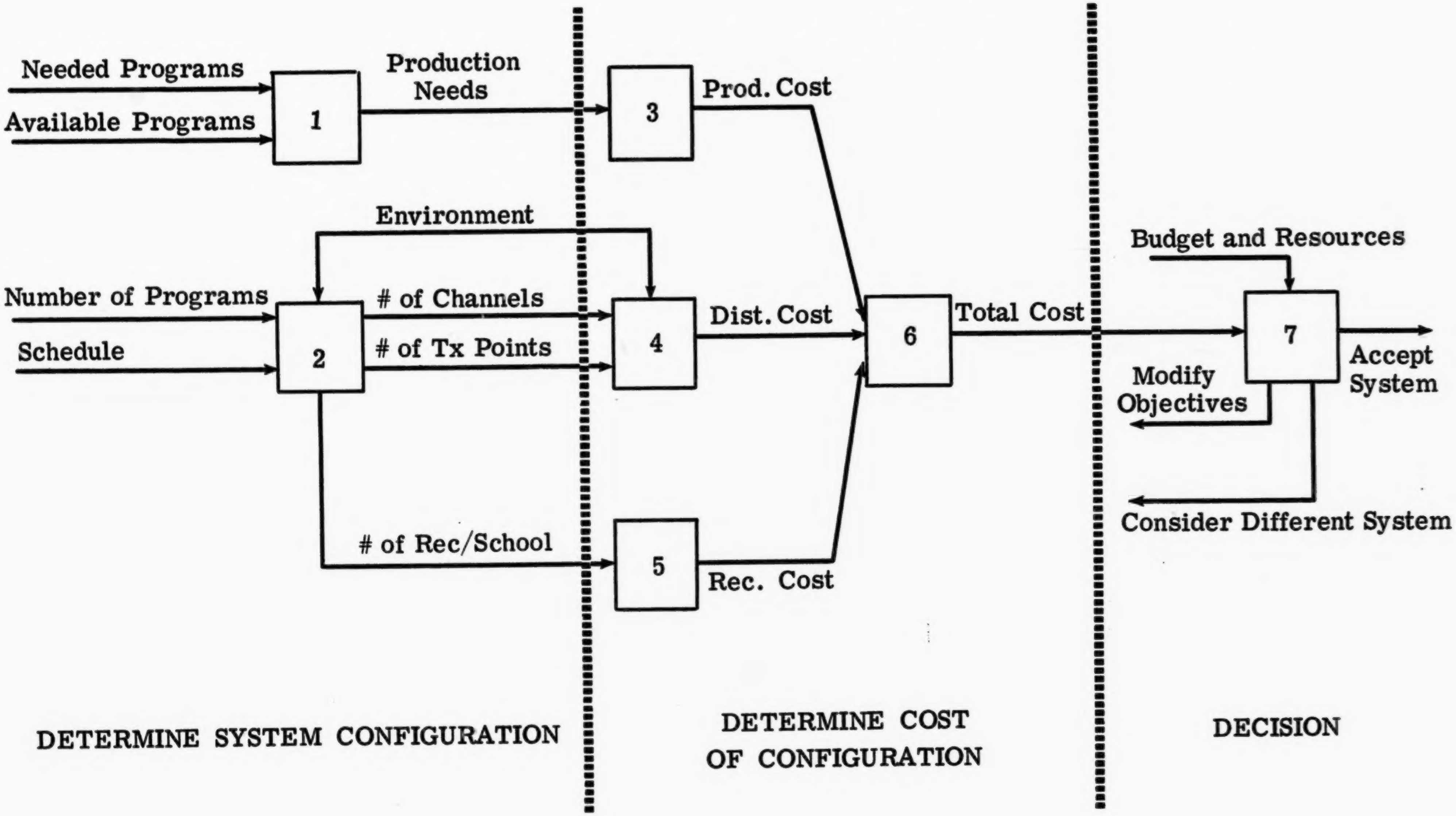

Needed Programs
Available Programs
1
Production Needs
3
Prod. Cost
Environment
Number of Programs
Schedule
2
# of Channels
# of Tx Points
4
Dist. Cost
6
Total Cost
# of Rec/School
5
Rec. Cost
Budget and Resources
7
Accept System
Modify Objectives
Consider Different System
DETERMINE SYSTEM CONFIGURATION
DETERMINE COST OF CONFIGURATION
DECISION

Figure 2 - Cost Determinations

COST COMPARISONS

In order to make a meaningful comparison of all systems, a common denominator must be defined. In this study, a hypothetical educational task was defined and the requirements to accomplish this task in selected environments were established for each system. A discussion of the rationale of this approach and a description of the task appears in Volume II of this study, the Technical Report. Volume II also contains the cost data collected and analyzed for each of the systems investigated, the format for comparing systems on a cost basis, a set of graphic presentations of several media system comparisons, and a detailed discussion of cost comparison results.

From the cost comparison discussion in Volume II, some general assessments have been made and are included in this volume. The assessment ratings of the various systems are presented in Tables 1 through 3 in terms of total cost, production cost, and distribution cost. No table was prepared for reception cost, because this cost was assessed as reasonable for all media systems. These tables provide a useful tool for the preliminary screening of media systems by considering the general cost appropriateness of a system within a particular environment. The final selection of a media system must be based on consideration of not only the comparative costs of alternative systems, but also the educational task to be performed.

General Information

Some general information applies to all three tables and may facilitate the interpretation of the data contained in them.

1. The instructional media systems being compared are defined in the Glossary, page 27 .
2. The types of environments — local, city, metropolitan, state, and region — are described in the Appendix, page 69.
3. Each assessment is relative to the costs of all other systems identified in the table and costs are calculated on a per pupil basis.
4. A system is designated as "not applicable" when the educational environment to be served is either too large or too small to be appropriate.
5. A system is designated as "not reasonable" when there appear to be significant cost differences between appropriate systems.
6. A system is designated as "reasonable but with production qualifications" when the current cost of producing and/or duplicating instructional material is too high in relation to the resources of an educational environment.

7. A system is designated as "reasonable but with technical qualifications" if lower costs depend upon development and refinement of equipment or changes in Federal Communications Commission (FCC) policies and regulations.

Table 1 - Total Cost Assessments

The ratings in Table 1, on the following page, show that total cost of television would be reasonable for local and city environments if problems of production cost were eliminated except for airborne and satellite systems.

Television production costs for equipment and studio facilities and for devising the content of the materials range from $200 to $2,000 per program. Only a very large school district can afford such substantial amounts. For the local and city environments, even the cost of duplicating materials prepared by others is quite high, though it is possible to obtain copies for approximately $2 per minute. At this price, it is reasonable to assume that a school system could afford one copy for use at a central transmission point.

Purchase of one copy is suitable for local or city environments that require only one transmission point. In the larger environments, more transmission points are needed - and therefore more tape copies - to avoid the cost of transmitting programs over greater and greater distances. This highlights the need for a technique of inexpensive, good quality duplication of video tapes. Even if this technique were developed, however, there are few materials generally available that are worthwhile duplicating.

The cost of producing instructional materials on film is relatively high. Therefore, the current practice is to purchase film prints from commercial organizations. The cost of film prints is also high because the volume of use is low, but high volume use is unlikely until costs are reduced.

The technical problems that qualify the reasonable rating of television systems on the metropolitan, state, and regional levels relate to distribution and are discussed under Table 3 - Distribution Cost Assessments.

Table 2 - Production Cost Assessments

The ratings contained in Table 2, page 18, show the assessments of the various systems in terms of production costs only. These costs are divided into two categories, the cost of producing original materials and the cost of obtaining duplicates. Production costs are essentially the same for all the television systems studied; therefore, all these systems are grouped together in this table.

Table 3 - Distribution Cost Assessments

Table 3, page 19, rates the systems on the basis of distribution costs only. In the case of television systems these costs would be reasonable if certain

Table 1.

TOTAL
COST ASSESSMENTS OF INSTRUCTIONAL MEDIA SYSTEMS

Instructional media system	Type of environment				
	Local	City	Metro	State	Region
Audio visual					
Airborne TV	NA	NA	NA	T	T
ITFS	P	P	☐	T	T
Satellite TV	NA	NA	NA	NA	T
UHF TV	P	P	☐	T	T
Closed Cir. TV	P	P	☐	☐	☐
VTR	P	P	T	T	T
Film	P	P	P	P	P
Audio					
Radio	P	☐	☐	☐	☐
Lang. Lab	☐	☐	■	■	■
ClassDialAccess	☐	☐	☐	■	■

KEY

Costs are:

☐ Reasonable
T Reasonable, but with technical qualifications
P Reasonable, but with production qualifications
■ Not Reasonable
NA Not Applicable

Table 2.

PRODUCTION
COST ASSESSMENTS OF INSTRUCTIONAL MEDIA SYSTEMS

Instructional media system	Type of environment									
	Local		City		Metro		State		Region	
	Orig	Dup	Orig	Dup	Orig	Dup	Orig	Dup	Orig	Dup
Audiovisual										
TV	▨	☐	▨	☐	☐	☐	☐	☐	☐	☐
Film	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Audio										
Radio	▨	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lang. Lab	☐	☐	☐	☐	☐	▨	☐	▨	☐	▨
ClassDialAccess	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

KEY

Costs are:

☐ Reasonable
▨ Not Reasonable
NA Not Applicable

Table 3.

DISTRIBUTION
COST ASSESSMENTS OF INSTRUCTIONAL MEDIA SYSTEMS

Instructional media system	Type of environment				
	Local	City	Metro	State	Region
Audio visual					
Airborne TV	NA	NA	NA	T	T
ITFS	☐	☐	☐	T	T
Satellite TV	NA	NA	NA	NA	T
UHF TV	NA	☐	☐	T	T
Closed Cir. TV	☐	☐	☐	☐	☐
VTR	T	T	T	T	T
Film	☐	☐	☐	☐	☐
Audio					
Radio	☐	☐	☐	☐	☐
Lang. Lab	☐	☐	■	■	■
ClassDialAccess	☐	☐	☐	■	■

KEY

Costs are:

☐ Reasonable
T Reasonable, but with technical qualifications
■ Not Reasonable
NA Not Applicable

equipment were developed or refined and/or certain FCC regulations were changed. In the case of the FCC regulations, the assignment of channels (spectrum space) for educational use seems to be the area of greatest difficulty.

Airborne TV

Use of UHF frequencies for an airborne system has been outlawed by the FCC. With minor redevelopment of airborne system equipment, telecasting on the ITFS frequencies would be possible. Although ITFS channels have been reserved for the Midwest airborne project, wide-area ITFS channels outside of that region might be extremely difficult to obtain.

ITFS

The ITFS system was designed to serve a local, city, or metropolitan environment. Wider area coverage is technically feasible, provided the present FCC limit on transmitting power is relaxed. Also, there have already been problems because of an inadequate number of channels in the ITFS band in Cleveland and Los Angeles. The use of either satellite or airborne multichannel systems on the ITFS frequencies would present additional spectrum space problems at ITFS frequencies.

Satellite TV

A regional satellite system is dependent upon application of certain recent technological developments such as integrated circuits which will probably take several years to implement. Developments in rocket and spacecraft component reliability could greatly affect costs. The question of frequencies for telecast from space is under international discussion. It is not clear what channels could be used for a satellite instructional service.

UHF TV

Greater utilization of UHF system is limited by the availability of channels. Most cities have only one channel reserved for educational television. Multiple channel instructional systems would require special FCC rulings along with modification of the Commission's existing policies of channel assignments. As larger areas are served more channels are needed because a wider variety of materials must be presented.

VTR

Placing a video tape recorder in each school is considerably more costly than the distribution of other television systems and will not be practical on a large scale basis until more reliable, lower cost equipment becomes available. However, because of its flexibility, a video tape recorder is useful in certain situations, such as those requiring immediate playback.

Closed-Circuit Television

The closed-circuit system is not limited in number of channels by any regulatory problems except possibly over long distances. The system is particularly sensitive to the density and management of schools. The costs may be prohibitive in some locations.

Cost of Computer Assisted Instruction

Computer assisted instruction (CAI) was not included on the cost assessment tables for several reasons.

Use of the computer for instructional purposes is relatively new compared to the media systems included in the cost assessment tables in the preceding pages, and is still considered to be in a research and development phase. Experience with computer assisted instruction is still too limited to provide sufficient data for estimating cost of using CAI in varying environments,and the nature of the system itself makes it difficult to compare CAI costs with other media costs in any environment. Some of the more obvious differences are as follows.

1. The cost of the basic equipment required for CAI is significantly greater than for any other media.
2. The cost of preparing instructional materials is increased by the need to put them in a format acceptable to the computer and the additional need for programs to control the operation of the computer and associated devices.
3. The computer offers the advantage of being able to process administrative data related to the operation of the school system and the test and evaluation data related to student and material performance in addition to presenting instructional material.
4. The computer can be programmed to control and utilize other media (film, slides, audio) as part of an instructional presentation.

While costs for CAI are difficult to estimate with any reasonable assurance at this stage, it is possible to make some general observations about CAI as an instructional tool, future trends in the utilization of CAI, and some of the difficulties still to be overcome before wide adoption of CAI is feasible. A brief summary of computer assisted instruction appears in the Appendix of this volume. The detailed discussion from which this summary was taken constitutes Volume III of this report.

Those interested in a discussion of the costs involved in the implementation and operation of a problem-solving type of CAI system are referred to "A Feasibility Study of a Central Computer Facility for an Educational System" performed for the U. S. Office of Education, Contract No. OEC - 1 - 7 - 07900 - 3565, which analyzes the functional requirements for a central computer facility having remote terminals in 50 educational institutions with a total enrollment of 100, 000 students, and makes preliminary specifications for such a facility.

COST-SAVING CONSIDERATIONS

One objective of this study was to investigate ways in which costs of media applications in education could be reduced. The second volume of this study, the Technical Report, contains a discussion of cost-saving possibilities and suggests changes that must occur in order to realize these possibilities.

Three areas can be identified where changes are necessary if cost savings are to be achieved. These areas are

1. the utilization of media systems,
2. the technology of media systems, and
3. the organization of educational systems.

Changes in these areas cannot be accomplished by the efforts of the individual educator alone. However, knowledge of the nature and scope of these changes is important to the individual educator if he is to apply his share of the effort for change in the most fruitful direction and if he is to prepare for the impact of change when it occurs.

A brief discussion of each of the three areas is presented in this section along with a description of one cost-saving configuration that might be possible if the suggested changes were made.

Utilization of Media Systems

Wide-scale adoption and more intensive use of the media will result in cost reductions on a per student basis in the areas of production, distribution, and reception.

Production Cost Savings

Significant savings will result if a production effort can serve a larger number of students. However, if materials are to be acceptable for widespread use, the quality of content and presentation must be improved by making more effective use of learning theory, techniques of student motivation, and curriculum needs of the schools. Preparation of materials in this manner would result in an increase in overall production cost but, through wider utilization, would also result in a decrease in production cost per student.

Savings in quality production are predicated upon the assumptions that the need for materials is relatively uniform in widely scattered school districts and that reliable, convenient distribution and reception systems would be available. The existing widespread adoption of the same textbook would seem to indicate that these assumptions are reasonable. However, some mechanism is needed to guide the production and distribution of materials for the newer media, and the cooperation of school districts is an essential ingredient in the development of such a mechanism.

Distribution Cost Savings

The distribution cost per student can be reduced if

- more students can be served from a central facility, or
- mass reproduction methods can be found for making inexpensive copies of original materials.

The scope of central facilities can be increased through the use of network television techniques — higher transmission antennae, increased transmission power, electronic relay of materials between school districts. Satellite and airborne television systems are also well-suited to covering vast areas containing large numbers of students. More intensive use of such methods can considerably reduce per student cost, but only if materials and schedules are appropriately tailored to the educational needs of participating schools. To accomplish this, transmission centers must have multiple channels available and schedules and materials must be coordinated.

The critical factor in lowering the costs of reproducing original materials is the anticipated volume of distribution. Unless the volume is large enough, the development effort required to find inexpensive methods of duplicating films and video tapes would not be worthwhile. Present copying techniques are based on high quality broadcast standards and low volume. Although high speed reproduction of video tapes is potentially possible, the techniques for accomplishing it have not been sufficiently developed because the expressed need has not been great enough. The price of a film print is many times the cost of making the print because of the low recovery rate of production and marketing costs. Assurance of a high volume market for copies of video materials or federal financing of the needed research of low cost reproduction methods would lead to cheaper means of copying video educational materials.

Reception Cost Savings

Savings in reception costs can be affected through

- increased student utilization of some portions of the reception system, and
- lower costs of components through the adoption of mass production methods.

Portions of the reception system would cost less per student if more student hours were devoted to the media. The central reception and distribution segments in the television systems are examples of areas where greater utilization would lower per student cost.

Application of technology to lower the cost of reception equipment components and to provide methods for duplicating instructional materials are discussed under Technology of Media Systems.

Technology of Media Systems

Cost savings through new technological developments emphasize individual use of media and may be considered in relation to audio, video, and audiovisual systems.

Audio Systems

Random Dial Access Systems. Instructional programs presently distributed via dial access are available only on a fixed schedule. The student must enter the system at precisely the right time to hear an entire program without waiting. It is technically possible, though not now commercially available at a reasonable cost, for a student to dial any program contained in a system at his convenience.

Record Player and Records. An inexpensive, slot-loading record player, now being mass produced, offers particular advantages for individual use by elementary students. It requires only that the record be inserted into the slot; once inserted it is played automatically. Certain models of this record player can accept vinyl records containing 10 to 15 minutes of material which may cost as little as $0.05 each when produced in quantity.

Audio Program Dissemination via Classroom TV. Existing classroom television receivers can be used to disseminate audio programs at a school-wide cost of less than $100. For a small additional investment, a remote audio source can be placed under complete teacher control.

Induction Loop Audio Dissemination. The use of audio materials usually requires either a loudspeaker or headset for the dissemination of sound. The headset generally requires wiring which tethers the user to one location. An induction loop may be used to disseminate sound to students who are provided with headsets which do not require any connecting wires.

Video System

This system introduces a low cost means of disseminating still visual frames via educational television channels for subsequent playback by the teacher in the classroom. The system will permit a central library to transmit up to 10,000 frames per hour to the requesting school.

Audiovisual System

Film Strip and Synchronized Audio. An inexpensive substitute for motion pictures is an automatic still projector and synchronized audio source. The programming may be taken from the existing inventory of sound motion pictures.

Integrated Audiovisual System. This system provides visual and audio frames on a common film medium system. Each visual frame has an associated audio frame which may, if desired, be repeated while the visual frame remains unchanged. It has a maximum capacity of 9,600 visuals and 80 hours of associated audio depending upon the production technique employed and the number of copies required.

Organization of Educational Systems

Behavioral objectives and the types of learning associated with the objectives have been identified as key elements in the process of media selection. The mode of presentation, group or individual, is also an important consideration in the selection procedure. If these elements play a part in the selection of a media system, it may be assumed that the need for both group and individually oriented systems will be recognized. Would this change the traditional school organization? Yes, because there are few provisions for individualized instruction at the present time. Could these changes result in "cost-saving" situations? Again the answer is "yes".

The largest item in a school's operating budget is teachers' salaries. The implementation of media systems will not necessarily reduce the number of teachers. It would alter their roles, however, so that they could devote a larger portion of their time to individual instruction and the guidance of learning experiences. This would be one step toward the achievement of optimum "cost effectiveness". The operation of media, the monitoring of learning experiences, and other similar responsibilities could be assigned to para-professionals. This work, currently performed by the teacher, could be effectively accomplished by persons without the professional qualifications expected of members of the teaching staff. Hence, a "cost saving" may result when a school system is organized along the lines discussed.

Cost-Saving Approaches

Cost savings are possible when new media systems are developed or existing systems are redesigned by implementing suggestions similar to those mentioned in this volume. The considerations presented in this section and the more detailed and expanded discussion contained in the Technical Report by no means exhaust the list of cost-saving approaches. They are offered, rather, to suggest some of the savings that are possible. The following example describes how these cost-saving considerations can be applied to a particular media system.

Educational satellite television is an attractive medium, especially from the point of view of cost. Its wider utilization can dramatically reduce cost per student per year. In the previous section on cost comparison of media, satellite television rated extremely well when applied on a regional level. Assuming the solution of some technical and spectrum space problems, the following satellite television system may be hypothesized.

A region, such as the southeastern section of the United States, might join in a cooperative venture to use satellite television as an instructional medium. A basic prerequisite for such a plan is that schools in these states reach some agreement on the instructional methods and content to be used in the media system. General agreements would have to be reached on management and administrative policies. The formidable array of detailed studies required in the planning, implementation, and operation of the proposed venture falls outside the scope of this report.

Assuming extensive use of the system within local schools, the cost savings in distribution and reception are fairly obvious. The wide use of the same instructional material would also reduce production cost per student.

Scheduling the presentation of material is a horrendous task. In order to provide some degree of freedom to local schools, a video tape recording system is proposed for each member school. Presentations could be recorded when transmitted,and played back at more convenient times through their closed circuit system. The expense of the video tape recording system would obviously raise costs, but without this additional system the usefulness of the satellite system would probably be seriously affected. Therefore, a trade-off between original system cost and the projected student use of the system is necessary.

Another major problem is the creation of the instructional material to be distributed from a central source. Member schools might be assigned the responsibility for generating material in specific subject areas. For example, a school in North Carolina could be assigned the task of developing instructional programs in high school economics. Local video tape recording systems could be used to produce the instructional material and the tapes could then be transported to the central television studio for editing and distribution.

It is important to point out that the satellite television system described above would not be the only media system in operation in the regional schools. Other types of media, operating on a local, city, or metropolitan basis, would present materials and provide learning experiences not appropriate for production and distribution by satellite television.

This brief discussion can only touch upon methods for presenting instructional material via a media system at minimum cost. It should be reiterated, however, that cost should never be the sole consideration. Emphasis must always be placed on the educational benefits which a medium affords to students. Instructional requirements, not cost considerations, should dictate the selection of media.

GLOSSARY

AIRBORNE TELEVISION	A television system in which the transmitter, antenna, and input equipment are mounted in an aircraft. Transmission from approximately 20,000 feet provides very large coverage patterns.
AUDIO	Of or pertaining to sound. Specifically, a sound recording. Loosely, any part of or all of the complex of sound equipment, facilities, and personnel.
AUDIOACTIVE	Facilities in which students are equipped with headphones, preamplifier, and microphone by means of which the student's voice is amplified and carried simultaneously to his own headphones as he speaks.
AUDIOACTIVE COMPARE	Facilities in which students are equipped with headphones, microphone, and a two-track tape recorder. The student's voice is recorded on the second track for playback and comparison with the voice on the master track.
AUDIOPASSIVE	Listening facilities in which students are equipped with headphones only.
CARREL	A student study station. Unitized desk, table or booth arrangement designed to facilitate effective independent study by students; may include electronic or optical devices for display of information — controlled either by the student or by outside programming sources — such as teaching machines and audio transmission and reception facilities.
CHANNEL	A complete system for transmitting a signal from an input location to an output location.

CLOSED CIRCUIT TELEVISION	A television system which limits distribution of an image to those receivers which are directly connected to the origination point by coaxial cable or microwave link.
CONDUIT	Rigid or flexible metal pipe or tubing which contains the wires that conduct signals or current.
CONSOLE, TEACHER'S	Instructor's control center in an electronic laboratory where a distribution panel controls the transmission of program signals and may include facilities for two-way communication with individual students or an entire group.
CONTROL CONSOLE	Equipment that incorporates monitors for viewing separate images picked up by various TV cameras in a system, in addition to the switching and other control devices required. When remote controlled cameras are used, special iris, lens focus, and pan-tilt circuits are included.
DIAL ACCESS SYSTEM	A system in which students are able to select and receive stored programs (audio and/or visual) from a location different from that of the receiver. The transmission from the source to the receiver is wholly or in part electronic.
ELECTRONIC LEARNING LABORATORY	Basically, a series of tape recorders, earphones, and microphones, connected by wire to a console where switches permit the instructor to communicate with (1) all students simultaneously, (2) groups of selected students, and (3) one student, individually.

FILMSTRIP	A length of 35mm or 16mm film containing a succession of still pictures intended for projection one at a time as slides are shown. Some filmstrips are equipped with a tape recording that contains not only the narration but also a subsonic signal that activates a solenoid to advance the filmstrip to the next picture on cue.
INSTRUCTIONAL TELEVISION FIXED SERVICE (ITFS)	An allocation of 31 channels in the frequency band between 2500 and 2690 megahertz to be used for educational television services.
HEADPHONE (also called headset)	A device consisting of one or two telephone receivers connected to a headband for individual listening to audio sources such as intercommunication circuits. Some headsets are equipped with a small microphone to permit two-way communication.
LANGUAGE LABORATORY	A room equipped for language instruction in which tape recorders, projectors, record players, and other devices are used singly or in combination.
LINE-OF-SIGHT	In television, a term that describes transmission characteristics of microwave frequencies. Such frequencies are usually limited in transmissions range to the radio horizon. Natural or man-made obstructions existing between the sending and receiving positions further limit coverage.
RANDOM ACCESS	The function of a tape playback unit that enables one to go to any storage location at any time and with equal facility and get a piece of information.

RECEIVER (BROADCAST)	Electronic instrument whose antenna intercepts the carrier wave of a radio or television station to which it is tuned, amplifies the signal, and translates the electrical energy into sound and, where applicable, picture.
RECORDER, VIDEO-TAPE	A device to record both the audio and video signals of a television production on a special magnetic tape which can be played back to reproduce the entire program.
SATELLITE TELEVISION	The use of a synchronous man-made satellite equipped to receive, amplify, and re-transmit microwave signals from and to specially adapted transmitters and receivers on the earth.
SIGNAL (BROADCAST)	The waves, impulses, sounds, pictures, etc., transmitted or received.
STUDENT POSITION or STATION	A desk, table, or booth with equipment that enables the student to receive a program and to react to it.
ULTRA HIGH FREQUENCY (UHF)	Wave lengths reserved for commercial and educational television which lie in the wave bands of 300 to 3000 megahertz.
VIDEO	That component of a television signal that contains the visual information.

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APPENDIX

SECTION A

METHODOLOGY FOR ESTIMATING COSTS

METHODOLOGY FOR ESTIMATING COST

The section on Cost Determinations introduced the methodology used in this study for estimating media system costs. The purpose of this section is to provide general guidelines for estimating the costs of the following media systems.

Airborne Television
Instructional Television Fixed Service
Satellite Television
UHF Television
Closed Circuit Television
Video Tape Recorder
Film
Radio
Language Laboratories
Dial Access

General guidelines can help the educator to understand the problems and some of the relationships between variables; they cannot provide solutions to all problems. Each application of a system in an actual educational setting is unique; no two systems can be applied in the same way and the accompanying problems are not identical. To estimate the cost of an actual system requires many value judgments and even guesses based on the facts and conditions that obtain in an existing situation. The variables have a large range of values and no general estimate based on an evaluation of a generic situation will quite fit actual conditions. Therefore, these guidelines are intended not as an inflexible method for estimating costs but as a tool to be used in the initial planning of a media system.

Categorization of Costs

Three categories used in this study for classifying media system costs are production, distribution, and reception. The number of unique programs to be produced is the key to determining production costs. The number of channels required and the number of central distribution points are the essential items in specifying the distribution costs. The number of receivers per school is a key item in determining the reception costs. This does not mean that these items comprise the majority of the system costs. It does mean that the first step toward outlining a system configuration has been taken when these items are specifically defined. They are the skeleton of the structure and determine the size and form of the system. The actual identifiable costs of other system components can be appended to this structure.

The costs of media systems may also be categorized as either capital (initial) or operating (annual) costs. Capital costs are associated with equipment, goods, or services with a useful value of longer than one year; they are usually associated with the initial planning and implementation of a system. Operating costs include goods and services which are purchased annually and are related to the operation of the media system. As in the case of the production, distribution, and reception categories, there is no clear separation of costs into either capital or operating. Therefore, the classification of some costs may be arbitrary judgment.

The following capital and operating costs are considered for each of the media systems investigated and for the three categories of production, distribution, and reception.

Capital Costs

- Initial planning
- Equipment
- Facility
- Initial software
- Initial teacher training
- Initial operator training
- Test equipment
- Expansion capability

Operating Costs

- Operating personnel
- Maintenance personnel
- Teacher training
- Operator personnel training
- Administration
- Equipment maintenance
- Replacement spare parts
- Facility upkeep
- Consumable supplies
- Related materials
- Current programming
- Program update
- Research, testing, and evaluation

Another consideration in estimating costs is to determine whether they are new costs or a reallocation of existing expenses. All of the costs which are assessed in this study are a direct result of the planning, implementation, and operation of the media systems under discussion. However, budgeting and accounting procedures often used in existing education systems do not separate costs according to media systems. Consequently, many costs which are estimated in this report would be charged to a category other than a media system. Generally speaking, the following costs might not appear on a school's accounts in the same way as they do in this report.

Facilities

Very often facility costs are not charged to a media system even though a definite portion of the facility is used solely for media. This might not be true of a remote repeater station or in cases where an entire facility is used for a media system. Generally, however, for accounting purposes, the cost of a building used mainly for instruction is not broken down into the types of instruction presented in the various sections of the building.

Facility upkeep costs of the smaller systems were not included in this study because it was assumed that each school has a custodial crew, and the additional cost of upkeep would be small or nonexistent. In the larger systems where building facilities are designed solely for the media system, facility upkeep is a measurable item. In this case, costs would be determined and each school would have to decide whether or not they would be an additional item in the budget.

Planning and Training

The initial cost of planning,teacher training, and operator training may not be additional costs to a school that has a planning staff, on-going teacher and operator training, and experienced technical help.

Many of the operating costs listed for planning and training may already be included in a school budget. If other media systems are in operation, operating and maintenance personnel may be on the payroll and no additional expense will be necessary. Also, if a media system is large, the size of the crew assigned to maintain that system may be large enough so that its cost would be a separate entry in the ledger chargeable to the media system. Therefore, the relative size of the specific media system under discussion will determine whether its costs appear in the school's accounts as separate items.

Related Materials

Related materials refer to those materials common to the administration of a school, e.g., duplicating supplies and paper. Costs for these materials have been estimated although they might be included in the normal budget for these items. This is also true of the programming, program updating, researching, testing, and evaluating functions inherent to a media system. If a school actively and continuously evaluates the curriculum, the costs of these activities for an added media system may be negligible.

The actual determination of the percent of media system costs which may be considered as "add on" costs would always depend upon the unique administrative, management, and instructional functions of the individual educational environment.

Common Costs

There are several functions which are common to all of the media systems. These functions and their estimated costs are discussed separately here, but are included in the total cost of the individual systems which are described beginning on page 39 .

Planning

The overview of the selection process described earlier discussed the steps which should be taken in planning a media system. The cost assigned to this activity depends upon certain factors in each unique situation. Also, as noted previously, the costs associated with planning may be expended from the current operating budget and, therefore, may not be charged to the media. However, for the purposes of estimating total system costs, the following checklist of items may be used in considering the expenses of planning. Expenses for facilities (including building, upkeep, and utilities), administrative and instructional support, and consumable supplies are not included because it is assumed that these expenses would be included in current operating expenditures.

Program Director
Curriculum Specialists
Media Specialists
Media System Designer
Facility Planner
Secretarial assistance
Legal services
Travel expenses

Administration

This function is associated with the administrative aspects of the media system and is not intended to include the administration of the total educational system. Because a large percentage of educators "wear many hats", the duties associated with media system administration may be one of their many assignments. Therefore, these expenses can be assigned to the media system administration budget, to other elements of the media system operation, or to other accounting units related to the operation of the total system. This decision must be made by the local planner. The size of the media system in terms of operating personnel and total expenditures will be the key factor in determining the unit to which this cost will be assigned.

The following list, which excludes facilities, may be used in estimating administrative costs.

System Director
Assistant(s) to the Director
Secretarial assistance
Travel expenses
Related materials
Meetings

Research, Testing, and Evaluation

The previous statements regarding the accounting units to which costs of planning and administration should be assigned also apply to expenses incurred in the research, testing, and evaluation activities associated with a media system. The checklist to be used in estimating these costs does not include expenses for facility, administrative and instructional staff support, consumable supplies, and related materials. These are assumed to be charged to the current operating account of the total system.

Research and Evaluation Director
Staff
Secretarial assistance
Travel expenses

Teacher Training

The teacher must perform a vital role in the efficient and successful planning, implementation, and operation of a media system. The planning activity must incorporate the ideas and views of the practicing teacher, and the research, testing, and evaluation activity must have adequate teacher support. Most importantly, the utilization of the media system depends largely on teacher acceptance and application.

To achieve full teacher participation,a program must be planned and implemented which will provide information to the teacher. This program may be referred to as teacher training.

Teacher training may take many different forms — summer institutes, in-service training courses, seminars, individual learning packets, etc. The costs associated with teacher training would depend upon the program planned for each unique setting. The following items are suggested as possible expenses which should be considered in estimating costs.

Director of Teacher Training
Staff (Instructors)
Secretarial assistance
Trainees (released time for teachers)
Travel expenses
Instructional materials
Related material

Expenses related to facilities, consumable supplies, and administrative support needed for teacher training are assumed to be covered by current expenditures. The determination of which of the teacher training expenses should be treated as "add on" costs must be made for each unique situation.

The remainder of Appendix A describes the estimation of costs for individual media systems.

Instructional Television Media Systems

Instructional television is used throughout the United States, and a variety of systems are available for delivering instructional television materials. The systems that were studied include airborne television, the instructional television fixed service (ITFS), satellite television, UHF television, closed circuit television (cable and microwave broadcasting), and video tape recorders.

Production

Since the production costs of television materials are independent of the delivery system, guidelines for estimating these costs are discussed without reference to a particular television system. However, individual system considerations are noted in the discussion of cost estimating guidelines for the distribution and reception systems.

Acquisition of Existing Materials. There are several sources from which to rent television materials, chiefly, the National Great Plains Instructional Television Library, the National Center for In-school Educational Television Instruction, and the Midwest Program on Airborne Television Instruction. If materials available from these sources can be matched to individual school requirements, it is less expensive to rent or buy them than to produce the materials at the same level of quality. A three step process should be followed when deciding whether to rent or produce television materials.

1. Review catalogs and select appropriate materials.
2. Screen selections and weigh rental cost vs. production cost.
3. Consider rented vs. produced materials with the final decision based on both cost and effectiveness.

It may be desirable to revise the original set of criteria if, during the review process, suitable television materials are located which are readily available. The costs of purchasing associated written materials and mailing and handling should be included in estimating the total cost of renting materials. Often prices may be negotiated or a barter agreement may be reached.

Cooperative Production. If the decision is made to produce materials rather than to rent or purchase them, costs can be reduced considerably if several groups cooperate to develop and produce materials with each participant receiving one or more copies of the material generated. Therefore, it is advisable to explore cooperative production with neighboring schools, state agencies, national curriculum groups, and other ITV groups.

Designing Materials. Resources should be invested in developing an overall design of the television materials to be produced. A series of programs should be outlined using the best ideas available nationally. If properly done, the materials will be useful to others who may be willing to share the costs of good planning and design. The efficiency of the design task will depend upon an adequate definition and measurement of educational goals. Usually, this can best be accomplished by utilizing the experiences and knowledge of specialists such as national curriculum leaders, local teachers and supervisors, ITV personnel, media researchers, and learning specialists. These consultants can outline instructional materials within subject areas by grade level for group and individual instruction.

Production Facilities and the Production Schedule. The school district may find it possible to have the recorded materials produced in an existing television studio facility. However, if the district has its own studio facilities, it must be remembered that a larger staff and facility would be needed to produce the initial materials than would be required for the continuing operation. The administrator must weigh the costs of contracting with an outside agency for production against the costs of in-house production to decide whether materials should be produced by the school system in its own facilities, in a local ITV facility belonging to or shared with someone else, or by commercial production groups.

The number of studios needed depends upon the number of programs prepared annually, the ratio of rehearsal to recording time, and the utilization of the facility. The number of hours required to prepare materials can be multiplied by the rehearsal/recording ratio and divided by the utilization factor after it has been multiplied by the number of hours the studio can be used per year. This will provide an estimate of the number of studios required.

A high utilization factor can be achieved only if sufficient lead time is given so that the studio time can be carefully scheduled. If the material has not been completely designed before rehearsals begin, scheduling is difficult. An intensive review and revision effort, extensive use of film, shooting on location, animation, or insufficient amounts of critical equipment or personnel will each create a low utilization factor.

Studios should be designed by a professional studio designer. It may be possible to use space in schools which is no longer desirable for classroom use. Production facility costs include costs for studio and auxiliary space (lighted, air conditioned, and wired), cameras, microphones, and other audiovisual signal origination equipment, control and switching equipment, test equipment, video and audio tape recorders, and studio designer services.

Development of Material Content. After the general outline of the required materials is prepared, a team of specialists should be recruited to prepare their content and determine their method of presentation. Some of these specialists would be responsible for the recording, testing, and revision phases of material development. The team would consist of teachers, content specialists, learning researchers, writers, testing and measurement specialists, and media specialists.

Production Operation. The principal technical requirement is the number of personnel required to record materials in the studio. This is determined by the number of studios and the quality of the materials. The number of cameramen, floormen, producer-directors, control room engineers, and video tape recorder operators is fixed by the studio design unless only minimal quality is desired. Savings can be made only by reducing the rehearsal to recording ratio or increasing the utilization factor of the studio because these operating personnel will generally be idle when the studio is not in use.

In addition to personnel costs, other costs which can be assessed by the engineering staff include those for power, camera tubes, film developing and processing, and art, engineering, and secretarial supplies.

After the content is designed and prepared, it must be recorded in the studio. Often these two processes go on concurrently although this is undesirable. However, since review and revision of the content is a continuing process, this overlap cannot be avoided entirely. For this reason, some of the material designers must be available during the actual production or recording process. The number and makeup of the team which records the material are highly variable. Often it is the same group that is responsible for the design of the material, but, most often, the group lacks sufficient numbers of learning, testing, and media specialists. Similarly administrative help and review and revision resources are often inadequate. This practice is unwise for the same reasons that inadequate planning is undesirable.

Additional costs for recording the content beyond the salaries of the specialists are purchase of rights to use copyrighted materials, props and other supplies for the recording of materials, salaries and expenses of secretaries and clerks for testing, script preparation, etc.

Distribution

The choice of a method of distribution for a television system is largely a function of the size of the area to be covered, the population distribution within the area, and the number of television channels needed. All of the systems can supply services on a single channel unless FCC regulations prohibit a new channel assignment in a particular area. Standard UHF systems and airborne UHF systems may be limited to one or two channels by regulation. ITFS systems are limited to a maximum of four channels. Closed circuit systems are not limited by regulation but by technical and cost considerations. Six-channel closed circuit systems are in use and twelve-channel systems are possible. Satellite broadcast systems are limited by regulation and technical considerations, but it would appear that ten or more channels are feasible.

The area of coverage of a system varies with transmitted power, antenna height, frequency, and the topography of the terrain. The following areas can be used for rough estimates.

System	Area - sq. mi.	Application
UHF	7,000	County
ITFS	300	City
Airborne	100,000	Small Region
Satellite	1,000,000	Large Region
Closed Circuit	N/A	Campus/School District

Closed circuit systems do not broadcast over areas, but connect individual schools to a program source by coaxial cable. The cost of this service depends on the number of schools in the system and the distance between the schools. For single channel systems, closed circuit is usually more expensive than other broadcast systems. However, when more than four channels are required, closed circuit may be the only alternative other than joining a national satellite broadcast system.

Although the area of application may be quite large, the population is usually not distributed uniformly. The majority of the students may be found in a few densely populated clusters within the total area. Thus, a few ITFS systems or a few closed circuit systems might reach most of the student population without resorting to a wide coverage broadcast system. Either ITFS or closed circuit systems can provide more channels than a broadcast system and their use would allow more local control over subject material and method of presentation.

The type of material and the amount of material to be presented will determine the channel requirements of a system. If only general material is to be presented and this material is applicable to the requirements of a large percentage of the student population, then few channels are needed. Examples would be current events and general cultural programs which would apply across a number of grade levels. This type of application lends itself to a single channel system. When subject oriented material is being presented to individual grades and when intensive student coverage is desired, then multichannel systems are required. If individual instruction is planned, the number of channels required becomes larger than any existing or planned television system could economically supply.

The following table provides a rough guideline to the availability of channels for each television system. The question mark indicates regulatory, technical, or cost problems which may bar use of that number of channels.

SYSTEM	NUMBER OF POSSIBLE CHANNELS						
	1	2	3	4	5	6	10+
UHF	Yes	?	No	No	No	No	No
ITFS	Yes	Yes	Yes	Yes	No	No	No
AIRBORNE	?	?	?	?	No	No	No
SATELLITE	?	?	?	?	?	?	?
CLOSED CIRCUIT	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Figure A-1 is a simplified illustration of the steps required to determine the cost of the distribution portion of a television system. The number of channels required will be a determining factor in choosing the amount of related equipment such as transmitters and tape recorders. The number of channels required may also eliminate some television systems from consideration. If six or more channels are found to be necessary to accomplish an educational task in an area, then systems which are limited to less than this number of channels by technical or regulatory restrictions will be eliminated from consideration. In some cases, the number of channels required could be so large that all television systems would be eliminated. To determine the number of channels required, the master schedule must be examined to find the maximum number of simultaneous transmissions. If, on a particular day, three different television lessons must be transmitted concurrently, then at least three television channels will be required.

The transmission points are the locations where the program material is placed on a particular channel. In a broadcast system these points would be the number of broadcast stations required to cover the area being serviced. In a closed circuit system, they would be the number of hubs in the system from which the video tape playback units, film chains, or camera chains feed the program material to the coaxial cables servicing the schools.

The number of transmission points in a system determines the amount of point-related equipment such as buildings, transmission antennas, towers, and transmitter groups. The number of transmission points also determines the complexity of the program distribution between the transmission points. A large number of transmission points spread over a large area would require a complex program distribution system or network to provide each station with programs at the proper time. This might be a microwave or coaxial electronic network, or a physical delivery system using trucks or the U. S. mail to distribute

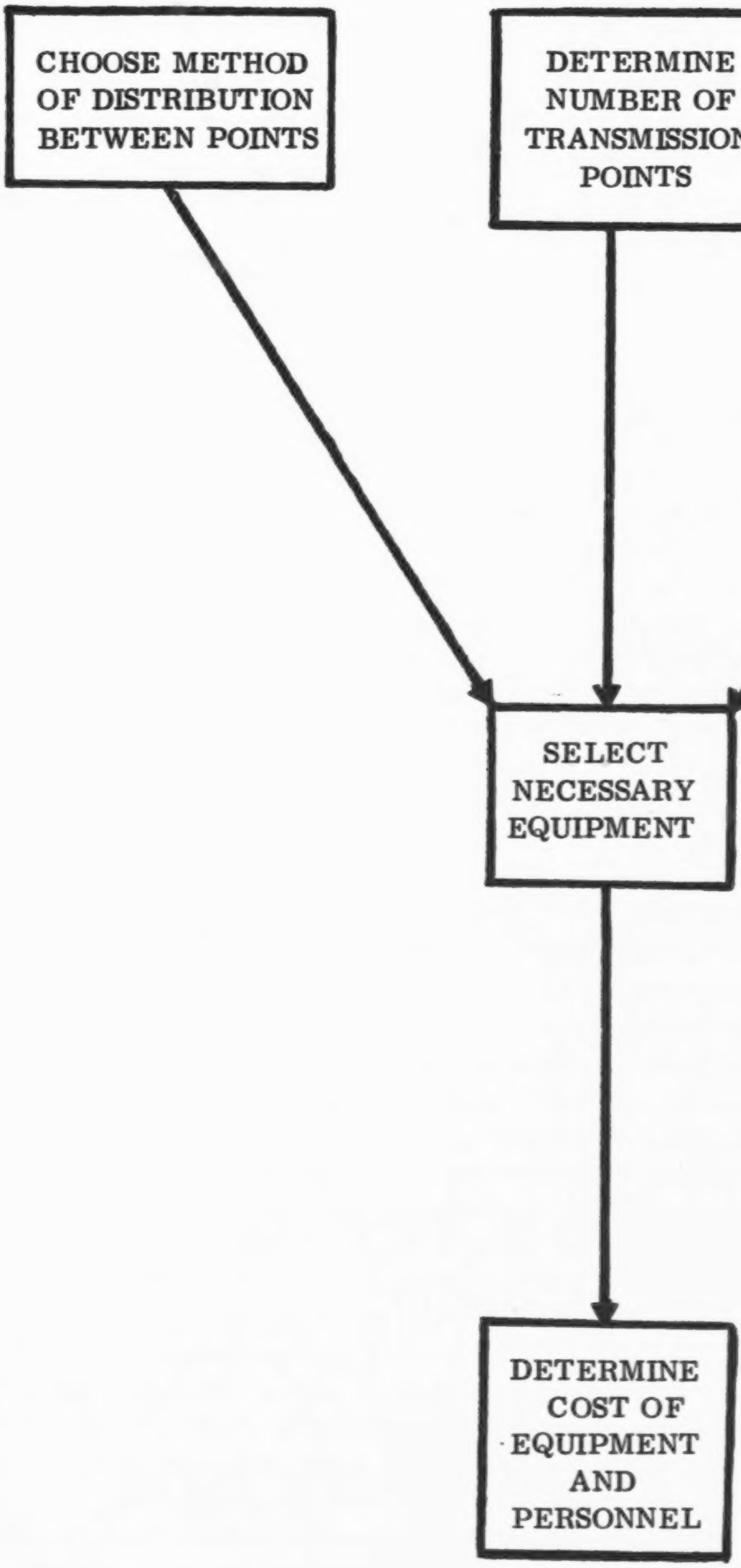
CHOOSE METHOD OF DISTRIBUTION BETWEEN POINTS
DETERMINE NUMBER OF TRANSMISSION POINTS
DETERMINE NUMBER OF CHANNELS
SELECT NECESSARY EQUIPMENT
DETERMINE COST OF EQUIPMENT AND PERSONNEL

Figure A-1. Determination of Television Distribution Cost video tape or film. The size of the complete system, the amount of program material to be transported, and the time allowed for transportation will affect the choice of a distribution system.

When the number of channels, number of transmission points, and method of material distribution between points have been decided, the amount of equipment and the size and number of facilities related to these factors can be determined. In reality, all of these steps should be accomplished by a consulting engineer who would follow a similar process for a number of candidate systems to allow some choice on the basis of cost versus system capability.

One of the outputs of this process would be a list of personnel, equipment, and facilities required to implement the distribution system. By assigning a cost to each item, an estimate of total distribution costs may be derived. A list of required items for a UHF broadcast system follows.

UHF Broadcast Station

Capital Costs

- Transmitter
- Spare tube set
- Control console
- Input and monitoring equipment
- Tower
- Antenna
- RF load and wattmeter
- Transmission line
- Line pressurization equipment
- Test equipment
- Land, site improvement, building
- Installation

Operating Costs

- Engineers
- Technicians
- Power and repair parts
- Building maintenance and utilities
- Tower maintenance and utilities
- Insurance

UHF Microwave Relay

Capital Costs

- Television relay equipment, fault alarm, and audio channel
- Antennas
- Wave guides
- Battery or other auxiliary power
- Building
- Tower
- Site improvement
- Land
- Multiplex filters

Operating Costs

- Technicians (including transportation to sites)
- Power
- Parts and repair

UHF Input Facility

Capital Costs	Operating Costs
Video tape recorders	VTR operators
Switching equipment	Clerk-librarian
Building costs	Control center operator
	Network chief engineer
	Supplies
	Benefits

Lists of the above type were compiled for each type of television system investigated. Reference should be made to Volume II, the Technical Report, for these distribution cost listings and for additional comments pertaining to design considerations.

Reception

The type of television system chosen and the number of television receivers required in each school are the starting points from which to determine the reception costs of a system. The number of receivers required in a school depends upon the program schedule. The television programs for each class must be scheduled to determine the number of receivers needed for the time period of maximum demand.

The in-school reception equipment can be divided into two groups, that which is common to all systems and that which is peculiar to each system. The following items form the basic equipment for all schools:

- Television receivers
- Receiver mountings
- Room outlets
- Wiring
- Distribution amplifiers

The basic equipment cost for each school can be determined from the number of receivers required per school.

The equipment which receives the signal from a central transmission point is different for each system of transmission and is listed below.

UHF Reception

UHF antenna
Preamplifier (optional)
UHF/VHF converter
Mast or tower

ITFS Reception

2500 MH_z antenna
Tower
Down converter

Airborne Reception

Antenna
Preamplifier
Tower
Down converter

Satellite Reception

Antenna
Mounting
Down converter

Closed Circuit Reception

Connecting lines between school buildings — leased from telephone company by the month

Maintenance for all reception equipment can usually be contracted for locally. The annual cost will be about 5% to 10% of the original equipment cost.

Audiovisual Media System

An audiovisual media system is comprised of projection equipment and film programs. Its basic components are motion pictures or still pictures with or without sound capability. Analysis of the production, distribution, and reception costs of this media system may be divided into two categories:

1. 16mm sound films and projectors, and
2. slides, filmstrips, overhead transparencies, records, audio tapes and their related projectors or playback equipment.

A system of 16mm sound films and projectors has the following characteristics:

Production - generally acquired from external sources
Distribution - necessitates a special facility (media center, audiovisual center) for scheduling, storage, and delivery of films
Reception - a 16mm projector and screen

A system of slides, filmstrips, transparencies, and related equipment has the following characteristics:

Production - program materials may be acquired from external sources or produced internally
Distribution - can be easily encompassed in each school building or existing book library if a special facility does not exist
Reception - each form of this media classification requires its own projector and a screen

Costs associated with the 16mm films and projectors are substantial compared to costs associated with slides, filmstrips, and audio tapes. The characteristics of the latter system are such that the necessary materials, equipment, and facilities could easily be accommodated in the system required for 16mm films and projectors at little additional cost. Therefore, in the interest of simplicity, the remainder of this discussion will focus on the costs related to planning, implementing, and operating a 16mm system with brief reference to the other category where appropriate.

16mm Film - Production

Film production is normally too expensive to be undertaken by most educational environments. Films are usually purchased from external sources such as commercial companies, government agencies, universities, and curriculum study groups. Therefore, the discussion of production that follows will be limited to the acquisition of films.

Once the instructional needs of students are defined, sources of programs should be investigated. There are approximately 10,000 educational films currently available from over 100 production sources. Of these, 47% were produced for the elementary grade level (K-6) and 38% were produced for the secondary grade level (7-12). Approximately 1,500 of these films were produced in 1966, 90% of them in color.

In order to match programs to needs, a representative committee composed of grade level and subject matter specialists should be formed. Their primary task would be to gather film catalogs, analyze their contents, and determine which existing films would satisfactorily fulfill the educational media requirements as they have been defined. They should then translate their needs into quantitative terms, specifying minimum and maximum limits if possible. The committee should then approximate an average cost per program taking into account price differentials between suppliers and between color and black and white film. The last and most important factor in determining total costs is to calculate the number of multiple copies (film prints) per film title.

Factors influencing the number of copies stem from the instructional requirements and the schedule determined by the school as adequate for serving them. Once these factors have been identified, the number of classrooms per building and the number of schools per area served should be taken into consideration, as well as the transaction time cycle of scheduling, delivering, and inspecting a film. These factors are used to compute the number of prints of each film program that must be purchased. The number of film prints is analogous to channels in a television system. This number may be derived by determining the number of scheduled simultaneous classroom presentations of each program title. The total number of prints is the sum of the number of copies of each program title.

16mm Film - Distribution

Films are distributed from an audiovisual center or an instructional materials center which is very similar to a book library. The audiovisual center screens, evaluates, and acquires films from external sources. It also catalogs, stores, schedules, and delivers the films to the schools that have requested them and repairs and maintains both projectors and films. A center may also provide these services together with production and reproduction facilities and equipment for media other than 16mm film.

The major costs associated with an audiovisual center are incurred at the time of its inception; namely, establishing the facility and acquiring the necessary staff and equipment. Figure A-2 illustrates the steps necessary to determine these costs.

Number of Shipments. The calculation of the number of shipments or volume of transactions is a key step in designing and estimating the cost of an audiovisual center. The two steps that precede the calculation are included in the figure to show the data upon which the number of shipments depends. Ideally, the investigation of the particular educational environment — number of schools, number of students, instructional objectives, number of simultaneous presentations of each film — would have been completed. Also, the total number of film prints for the estimation of production cost would have been determined. However, this data may not be available in the early stages of system planning; therefore, an alternative method is suggested for cost estimation purposes.

The number of shipments per month of a film print may be estimated first be determining the time required to service a film print in the

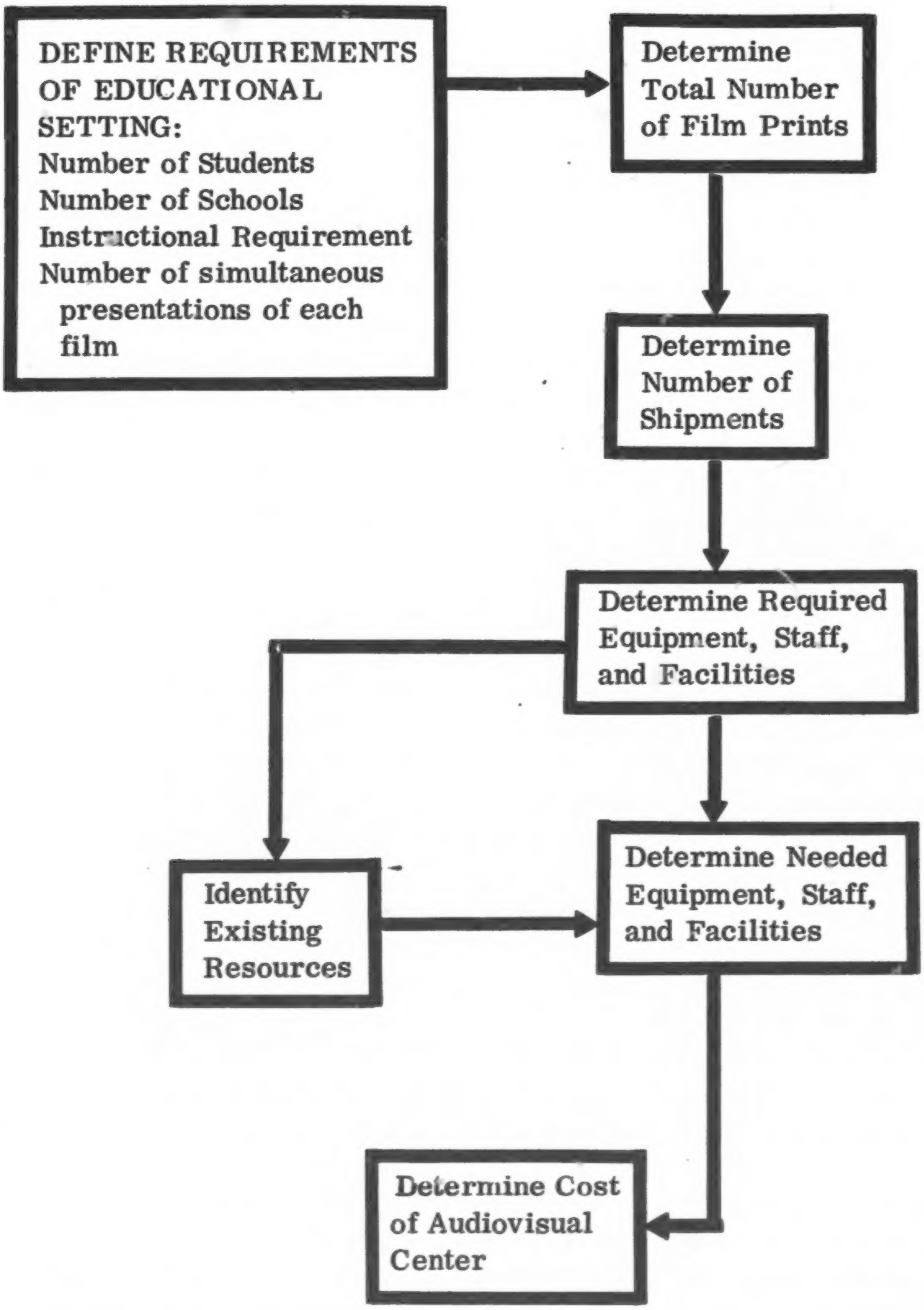
DEFINE REQUIREMENTS OF EDUCATIONAL SETTING:
Number of Students
Number of Schools
Instructional Requirement
Number of simultaneous presentations of each film
Determine Total Number of Film Prints
Determine Number of Shipments
Determine Required Equipment, Staff, and Facilities
Identify Existing Resources
Determine Needed Equipment, Staff, and Facilities
Determine Cost of Audiovisual Center

Figure A - 2. Determination of the Cost of an Audiovisual Center for the Distribution of 16mm Films media center prior to shipment,and then by estimating the length of time a print will remain in a school for instructional purposes. By adding service time to the time the film is in the school and dividing the sum into one month (20 school days), the number of maximum possible shipments of a film print per month may be estimated. Multiplying this rate by the total number of film prints would give an estimate of the total number of shipments per month. For example:

1 day service time + 4 days in school = 5 days required for 1 shipment of a print

20 school days ÷ 5 = 4 (no. of maximum possible shipments per print per month)

4 x total no. of prints = total no. of shipments per month

It should be emphasized that the number derived by this method must be reevaluated when the instructional requirements have been specified.

The number of shipments serves as the basis for defining the size of the audiovisual center, the amount of equipment, and the number and qualifications of staff members.

Facilities. The audiovisual center has traditionally stored and circulated a variety of instructional materials and devices. The facility requirements of the center include ample space for its staff, materials storage, reception area, small production facility for non-16mm film media, and a screening area and conference room for evaluation purposes. Housing of a center has ranged from a floor of an existing school building to a separate building. Distribution service in the past has varied widely depending upon the number of schools to be served, and no standards have been established for a media center regarding the number of schools or students to be served. As space requirements are applied to the larger environments, it is assumed that multiple media centers would be employed to meet the task assigned to the media system, i.e., regional environments would have a network of media centers to serve an entire geographical area.

Equipment. The most expensive distribution equipment includes trucks, electronic film inspection machines, and film storage racks. Other equipment such as desks and minimum test apparatus for repairing projectors is less expensive.

The number of trucks needed depends upon the number of film deliveries one truck can make per day, the mileage between schools, and the volume of shipments.

Electronic film inspection machines are needed to clean, treat, and repair films. A film print is generally inspected upon its return to the center after a presentation in a school. The number of prints that can be cleaned and repaired in a day depends upon the type of machine and the skill of the operator. Each machine requires a full time operator.

There are only a few models of storage racks from which to choose. These hold a fixed number of prints of long and short programs and require a fixed amount of floor space for easy accessibility.

Staff. When estimating the size of a staff for an audiovisual center, variables pertaining to school district size and organization are of primary importance. Each center should have a director responsible for all of its activities. The number of assistants required depends upon the size of the area served and the manner in which the center is organized. In a smaller district, it is advisable to have at least two media specialists, one for elementary and one for secondary grade level materials. As a center becomes larger, further delineation of authority and responsibility by function is in order to achieve optimum cost efficiency. Salaries are commensurate with a locale's existing practice and are analogous to other professional classifications (teacher, librarian, etc.). The number of support staff members depends entirely on the volume of transactions of the center. Estimates can be derived by timing the unit transaction of the jobs to be performed.

Investigate Existing Resources. Once facility, equipment, and staff requirements for the audiovisual center have been determined, it is extremely valuable to investigate resources which already exist in the school and may be adapted or expanded for the distribution phase of the audiovisual system. This would minimize additional expenditures which may be necessary.

If a school district has an existing facility which can be adapted for use as a media center, cost savings can result. If new construction is necessary, it is important to have a functional layout that can be expanded as needed. Location is of primary importance; it is helpful if a center is convenient to all associated schools. A central location would decrease delivery time, and consequently would be less costly than a peripheral location.

Another resource that may be in existence is a system of delivering mail within a school system which could be expanded to include films. Vehicle and driver costs can then be shared and allocated to dual accounting classifications. Many large centers which are part of state affiliated universities and serve a large student population or area may utilize existing postal or independent delivery services.

Many members of the existing teaching staff may have had experience with film media. Their assistance in planning and implementation can save time and help to avoid needless difficulties.

Once an inventory of existing resources has been taken, other ways to accomplish the task of distribution should then be investigated. Renovation or new construction costs on a square foot basis, as well as the unit costs for equipment and salaries, are gathered at this time.

8

16mm Film - Reception

Before a teacher and a student can interact with a program, a projection screen, a projector, and a film must all be assembled in the classroom. Usually the teacher or a student is adept at operating the projector. Projector and screen costs vary little among manufacturers. Volume purchase, however, offers discount possibilities. Maintenance and repair service for projectors is generally available from a local audiovisual dealer.

The primary cost determinant concerns the projector to classroom ratio required to perform the educational task. This ratio can be derived from a school's master schedule of film programs in relation to classes per grade level. Another factor that enters into the ratio is the number of classrooms per grade and per building. It is wise to store projectors in school buildings than to store and distribute them from a center.

Radio

Radio, as an educational medium, is marked by its broad base of service and the wide set of educational, informational, and cultural services which it provides. It is used directly in the classroom and, in addition, provides supplementary instruction for informal and formal adult education.

Educational radio, in the form considered in this study, is principally FM, although a number of standard AM educational broadcast stations are currently operating.

With radio, as with television, the configuration of the system determines the cost. Since much of the methodology used in estimating television costs applies to radio as well, the following discussion will concentrate on those elements unique to radio. The configurations considered in this report are:

Single Channel FM Broadcast
Multiplex FM Broadcast (multiple channel broadcast and reception)
EDUCASTING * (An existing version of Multiplex)

Production

The production costs of radio are independent of the costs of the transmission and reception systems. Therefore, guidelines for estimating these costs are discussed without reference to single or multiple channel distribution systems.

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* Patented method of instruction using FM channels to transmit course materials.

The principal factors in the costs of producing radio materials are the required number of programs, the allocation of local production facilities, and the location of the studio facility in relation to the transmission site.

Acquisition of Existing Materials. In practice, many educational radio stations obtain programs from external sources primarily because they can be acquired at little or no cost. As in the case of television, there are many sources which provide audio materials. Two primary sources are the National Educational Radio Network and the Eastern Educational Radio Network. Many materials are available at low cost (Broadcast Foundation of America) or at negligible cost. If existing materials can be adapted to the instructional and community service needs of the educational station, it is far cheaper to utilize these materials than to produce them. However, much of this material is old and was not designed for instructional use. A careful review of available materials should be undertaken and an assessment made of its value for the level and type of programming planned.

Designing Materials. Much of the present and future use of radio as an instructional and learning tool hinges on the imaginative use of the medium. Certainly, utilizing the best ideas and techniques developed by other stations is essential. Experience would indicate, however, that effective programming can be achieved by assessing local requirements and then developing programming designed to fit these needs.

The following elements should be an integral part of the design of radio programming for instructional or enrichment purposes. First, a determination of those curriculum areas that might best be served through the use of radio should be made. Having determined these broad areas, then it is of considerable value to write, produce, and test several kinds of programs for each grade level. After the effectiveness of these sample programs has been evaluated, a coordinated series of audio programs and supporting materials can be developed.

Development of Material Content. After a general outline of the required or desired audio learning materials has been prepared, it is customary to recruit a team of specialists (teachers, audio production experts, evaluation specialists, etc.) to prepare the content and to develop, test, and implement the audio materials.

Production Facilities and Program Support. The design of a typical radio studio will include production areas, voice recording and announcing booths, and a control room. The design of the studio is dependent upon the number of instructional programs to be produced and transmitted. A professional audio designer should be used to plan the studio facility and to aid in deciding when requirements dictate the need for more than one studio facility.

The two factors which determine the number of studios required are the number of programs to be produced and/or transmitted during a given period of time (a production cycle) and the maximum number of programs which one studio is designed to accommodate. Dividing the first factor by the second factor will provide the number of studios required.

There will be at least one control room for each studio facility. Usually a control room services more than one sound studio, although in more elaborate facilities there may be one control room per studio. The number of program control consoles required per facility and the size of each console is dependent upon (1) the diversity of program input sources, (2) the number of program input sources, and (3) the level of technical competency of console operators. The number of program sources (microphones, record transcription turntables, tape record/play units) required depends upon the maximum number of programs to be recorded simultaneously in addition to the sources required for "live" broadcasting. As with the balance of the technical audio components, the quality of the program console, i.e., its electronic specifications, should match the specifications for the various program sources.

Also during the design stage, consideration should be given to how the studio will be used. It may be used for demonstration purposes, audience participation programming, as a classroom or part-time maintenance facility (for joint studio-transmitter sites), or for large and small group recordings.

Production Operation. Audio production facilities will include "initial software" — prerecorded records and tapes. In addition, reel tapes (blanks for program recording purposes) must be provided to meet the maximum number of programs to be produced per production cycle less the number of tapes to be played "on the air" during a production cycle, with the provision for tape replacement on a regular basis. Under heavy, regular use conditions, this can amount to about 20% per year.

The actual number of production personnel which will be required will depend upon the scope of the production facility and the number of programs to be produced during any one cycle. Other key factors will be the number of hours of daily operation and the number of program consoles in the facility.

Other cost items, e.g., teacher-performers, content and measurement specialists, and the materials to support the programs, are related to the level, complexity, and number of programs produced during any production cycle. Additional costs beyond the salaries of those preparing and recording the materials are the purchase of rights to use copyrighted materials, sound effect sources, and the administrative expenses of secretaries and clerks.

Distribution

The type of material and the volume to be presented will determine the channel requirements of the radio system. If the material is of general interest and is applicable to the requirements of a large segment of the total potential audience, then only the main FM carrier may be used. This will be true for much of the community service enrichment and in-class instructional material which can be utilized across a number of grade levels. Multiple channels are required for the level of branching program featured with EDUCASTING or for programs directed at relatively small, selected audiences. As with television, the channel requirements for individual instruction exceed existing economic and technical feasibility. Figure A-1, used to plan the distribution requirements and costs for a television system, can be used to organize the planning of multiple-channel radio systems as well.

The number of channels required will be a central factor in choosing related audio equipment such as subcarrier generators and tape recorders. If a master schedule indicates that a number of programs are to be broadcast simultaneously (up to four under existing multiplex rules) then this will determine the channel requirements.

Each station will require a transmitter of appropriate power and quality, tower, antenna, console control equipment, supporting test equipment, input amplifier, and leased telephone lines (or microwave channels) from the studio to the transmitter, unless the studio/transmitter site is common to both.

If the system is to have more than one channel of simultaneous programming, one multiplex generator per channel is necessary together with transmission lines and antennas. For emergencies or occasional origination of specialized programming, it may be desirable to have a small studio, microphone, and transcription turntable or tape deck at the transmitter site.

Personnel requirements will depend upon the power level and the complexity of the equipment. It may be necessary to have a full time engineer or engineers in addition to operating transmitter technicians (students may be used) to meet scheduled operating hours and FCC requirements.

Reception

There are two basic configurations of radio reception equipment. The first is a distribution system within a school with a central antenna, receiver, and amplifier which feed individual speaker/amplifiers in each classroom. The second configuration provides individual or self-contained receivers in each classroom. Recently, individual FM receivers with associated tape record/playback units have been developed that allow the recording of instructional materials during noninstructional time which then can be played back at teacher or student convenience.

Operating costs of reception equipment will depend upon the number of technicians required to maintain the equipment plus the cost of spare parts.

Language Laboratories

A language laboratory is a system used primarily in the teaching-learning of pronunciation and aural recognition of foreign languages with equipment that may be controlled by either the teacher or the student. As the degree of control granted the student is increased, the equipment configuration changes and becomes more expensive.

Production

Language laboratory materials are plentiful and relatively inexpensive. It is not generally recommended that a school produce its own materials unless there are no materials available commercially. Costs for the acquisition of materials may be estimated by following the production guidelines outlined for audiovisual materials (page 48). When the production of materials becomes necessary, the following points must be considered.

1. The material is linguistic and there may be subtle nuances in the language which the student must discern; therefore, a recording system capable of high fidelity recording and reproduction is mandatory.
2. A quiet room with good acoustics is required as a recording studio. Usually, the language laboratory itself will meet these requirements.

Production costs are essentially facility and equipment costs with the addition of salary costs for instructors and/or technicians. Items which must be considered in the determination of production costs are the following:

Master tape recorders
Tape duplicating machines
Audio control console
Microphones
Tape splicers
Recording studios
Control room facilities
Tape storage racks and space
Technical personnel
Curriculum development personnel
Announcing or recording personnel

Distribution

The number of program channels required depends upon the number of different lessons which will be distributed simultaneously to the students. Once the number is determined, the required number of tape recorders, record players, radios, and teacher's voice channels may be specified. In addition, switching capability for distributing lessons is required. The switching system may provide the instructor with the option of listening in on either an individual student's response or lesson, and/or talking to one or a selected number of students. Each of these capabilities represents an increase in the complexity and cost of the switching equipment.

The amount of tapes necessary for use in an active-compare laboratory depends upon the time lapse between request and receipt of duplicated material. It is most expensive when the tapes for an entire semester must be ordered in advance. Here, the only recourse is to order one copy for each student of every master tape used in the course in order to ensure that the tapes will be available.

The cost of tapes is most economical if a blank tape is supplied to every student and the lesson is duplicated on the student's tape when he requests it. The seemingly endless reusability of tape makes this scheme practical. However, this arrangement requires the use of a high speed tape duplicator in order to produce a copy in a reasonable amount of time.

The calculation of distribution costs for passive and active systems is identical. The distribution system consists of the instructor's console and the wires leading from the console to the student positions. The instructor's console is ordered and priced in the same manner as a new car; the basic shell is ordered, and then the proper number and type of accessories are added, e.g., record player, tape recorder, switching unit, and instructor's microphone and headset.

The distribution cost in an active-compare system is the cost of duplicating tapes. The cost of the original tape is assigned to the production category. To calculate duplication costs, the cost per blank tape plus the cost of an operator's time to duplicate the tape is multiplied by the number of copies produced.

Wiring and installation costs vary depending upon local prices. As a rule of thumb, electrical installation costs in a new building can be considered the same per student position as the cost per receptacle of installing convenience outlets.

Distribution costs include consideration of the following items:

- Instructor's console
    - Switching unit
    - Tape recorders
    - Record players
    - Microphone and headset
    - Wiring and installation
- Duplicate tapes
- Operating and technical personnel

Reception

The single item common to all language laboratories is the student's headset. In the active systems, in order to minimize disturbance between students, each student may also have his own carrel. If the active system is audio only, the student will be furnished with a microphone and a small amplifier. If the system is audio active-compare, each student will also have his own tape recorder which will contain the small amplifier mentioned above. In the active-compare system, lesson distribution could be controlled by distributing individual lesson tapes, and the instructor's console could be eliminated.

Reception costs are a function of the degree of student-system interaction. The greater the interaction, the more complex the equipment and the higher the cost. The equipment required in a passive system includes chairs, headsets, and jackboxes into which the headsets are plugged. An active system would have all of the equipment found in a passive system plus microphones, amplifiers, and carrels. Every student position would have these items; therefore, the cost of reception equipment is the number of student positions multiplied by the sum of the individual costs of every item at a student position.

In an active-compare laboratory, student positions will consist of carrels, chairs, and tape recorders (includes microphones and headsets). To calculate costs, the number of student positions is multiplied by the sum of the cost of a tape recorder, a carrel and a chair.

Installation considerations for both active and passive systems are dependent upon the existence of the building in which the laboratory is going to be housed, and upon a need to have students move around while the program is in progress.

Briefly, items to be considered in calculation of reception costs are:

Carrel and chair
Tape recorder
Microphone and amplifier
Headset
Jackbox
Facility space

Laboratory Design

The size and number of language laboratories required by a school is a function of instructional requirements and student demands. The values of the following variables are necessary input in designing a language laboratory system for a high school.

1. The number of language course sections that would require the use of a laboratory.

2. The average number of periods per week each section will use the laboratory (may be a fractional number).
3. The number of class periods per week that the laboratory is available for use.

If the number of sections multiplied by the average number of required periods is less than the number of periods the laboratory is available, then only one laboratory is required, if it accommodates the largest number of students that would ever be in the laboratory at one time. However, if that product is larger than the number of periods that the laboratory is available, then whatever number of times greater it is denotes the number of laboratories that would be required.

A different approach is taken to the use and, therefore, the design of the system at the college level. It is assumed that there will be one laboratory of sufficient size to handle the number of students who would be expected to use the laboratory at any one time. In order to calculate the optimum size, the following information is required.

1. The total number of students who are studying foreign languages.
2. The average number of hours per week each student must spend in the laboratory.
3. The number of hours per week the laboratory is available for student use.

The total number of students multiplied by the average number of hours per week each student spends on the system yields the number of hours of student demand per week. The number of hours of student demand per week divided by the number of hours in a week the system is available provides the number of student stations required if all stations are used continuously every minute that the system is available. It is recognized that the occurrence of this situation is highly improbable, and that students will put varying demand loads on the system at different times of the day.

The problem of uncertain, varying student loads can be met in a number of different ways. As the use of laboratory facilities becomes more convenient to the student, it becomes more expensive to the school, a condition which indicates the likelihood of a compromise.

Dial Access Systems

Dial access systems have evolved directly from language laboratories and are used primarily to make a variety of stored educational materials readily available to the student. The program source is located remotely from the student and the information is distributed electronically.

Both audio and audio-video systems are available. The video operation is basically a closed circuit television system with switching to permit proper distribution and, consequently, all of the comments related to production, distribution, and reception of closed circuit television apply to the video portion of dial access systems. Attention is directed primarily to a dial access system that presents only audio material in the discussion that follows.

Production

On the basis of current practice, materials presented on an audio dial access system are primarily adapted from teacher-prepared lectures; consequently, a high quality, well staffed production center is essential for utilization of this system.

The previous discussions of the production of materials in the subsections on instructional television, radio, films, and language laboratories are all germane to the costs and techniques of producing materials for dial access systems, except that multiple copies of the material are not required. Audio programs are recorded originally on master tapes. Four master tapes are duplicated on to one four-track tape to be used for playback on the dial access system. Master tapes are never used for actual distribution; only duplicate tapes are played back to the student. This means that recorders must be available for the duplication procedure; however, a special duplication machine is not recommended.

To summarize, the major items which contribute to production costs are:

Master tape recorders
Audio control console
Microphones
Studios
Control room
Performing personnel
Technical personnel
Curriculum development personnel

Distribution

In order to decide upon the number of tape players that would be required in a dial access distribution system, the maximum number of programs that would ever be played at one time must be determined.

The tape players may be either single-track or four-track. A single-track machine is used for programs that are expected to have a small audience, and which are started upon call-up by the student rather than on a preset schedule. A four-track machine is used to play programs that are started automatically and simultaneously. It is desirable to have as many programs as possible presented in this fashion because it is more economical than the single-track presentation. The calculation for the number of four-track players necessary is:

$$\frac{\text{(Programs per week)} - \text{(Programs on single-track machines)}}{4}$$

Four-track players cost essentially the same as single-track, dial start machines; the total cost of tape players is the number of tape players multiplied by the cost per player.

The necessary switching equipment is a matrix of switches and wires. The size of the switching network is a function of the product of the number of program sources and the number of student stations. If 300 student stations must be connected to 100 program sources, 30,000 switching circuits would be required. Cost of switching equipment can then be determined on the basis of actual product prices. In the course of this investigation, repeated calculation by this method demonstrated that the cost can be closely approximated by multiplying the number of circuits by a factor of 2.5. Thus, a dial access system requiring 30,000 circuits would cost about $75,000. As the number of circuits approaches 2,000,000, the cost per unit decreases slightly. At this level, a factor of 1.5 can be used to estimate the cost.

Every program channel must have an associated audio amplifier to provide ample volume to every listening station. The cost of audio amplifiers is proportional to the number of program sources. To calculate the cost, the number of program sources are multiplied by the cost per amplifier. The cost of amplifiers is also affected to a slight degree by the number of student stations. The more student stations there are, the larger the amplifiers must be. However, if students use earphones rather than loudspeakers, large, expensive amplifiers would not be required.

The major distribution cost items are:

Playback machines
Switching equipment
Equipment installation

Facility
Operating and maintenance personnel

Reception

In designing a system, the number and location of student positions must be determined. The number of student positions is a function of the number of programs and the variations of student loading. This information is derived from administrative and instructional factors.

Reception equipment costs are those associated with the purchase and installation of the hardware comprising the student stations. Installation costs are approximately 3% of the equipment costs, which include a carrel, a chair, a headset, and a dial set for each student station.

Facility costs may be calculated in a number of ways. One method is to select the number of square feet necessary for each student position, multiply by the number of student positions, and multiply the product by the current average per square foot school construction cost.

The major reception cost items are:

Student Stations
    Dial Sets
    Headsets
    Carrels and chairs
    Installation
Facility

SECTION B

COMPUTER ASSISTED INSTRUCTION - A SUMMARY

COMPUTER ASSISTED INSTRUCTION — A SUMMARY

It is the purpose of this section to provide the reader with a brief overview of computer assisted instruction, its application to the instructional process, and its relationship to the other educational media systems under study. For an in-depth presentation of CAI and its potential the reader is referred to Volume III of this report.

For the purpose of this study, computer assisted instruction is defined as the utilization of remote computer terminals and real-time processing as an aid to the instructional process. The state-of-the-art in CAI hardware development indicates that two distinct forms of CAI media systems have evolved. Due to the substantial differences in equipment availability, cost of development of curriculum materials, and application techniques of the two CAI systems, they will be considered separately in this study. The two types of CAI media systems are: (1) CAI - teletype and (2) CAI - multi-device.

The first category of CAI media systems (CAI - teletype) is composed of that set of computers that provide multiple remote typewriter or teletype terminals. These computer systems usually possess teleprocessing capabilities. That is to say, the computer is capable of operating geographically remote terminals via standard data communication lines — telephone lines. For example, a computer in California is able to simultaneously service remote terminals in Ann Arbor, Michigan; New York City; Morehead, Kentucky,or practically any other school in the country. The student terminals utilized in such a system are presently limited to keyboard input-output devices. Examples of such hardware systems would be the GE-200, 400, and 600 series, IBM 360 (Model 40, 50, 65 series), IBM 1410 and 1440, RCA Spectra 70/45, plus several systems by other manufacturers. Such systems can presently service upward of 30 individual terminals and are primarily used for individual student problem solving, drill and practice exercises, simulation programs, and a limited amount of tutorial dialogue.

The second group or category of existing CAI computer systems provides a multi-sensory or multi-device terminal to a smaller number of individual stations located within close proximity to the computer. The student terminal for this type of CAI system may consist of any combination of a cathode ray tube (CRT), a strip film projector, a typewriter, and an audio unit. All of these terminal components are available today, with the exception of the audio unit which is expected in late 1968 or early 1969. Each terminal component is under the direct control of the computer. Examples of such systems are the IBM 1500-IS and the Philco-Ford 2000-201 SAVI System. Both of these systems have the capability of servicing up to thirty-two individual student terminals.

The various sensory and display capabilities of such an audiovisual student CAI terminal provide for a broader range of curriculum applications than does the CAI - teletype system.

CAI Applications

A survey of on-going CAI activities indicates that there are approximately five basic CAI techniques presently being utilized in CAI course development. The actual extent and application of these basic techniques varies with grade level and CAI equipment configurations. However, the techniques will be described in this summary section without regard to hardware limitations; the reader is referred to Volume III for complete descriptions.

Tutorial Design

One of the most widely developed CAI techniques is the tutorial dialogue between a student and the computer. This technique is characterized by (a) the presentation of learning material to the student in various step sizes, (b) a question or test item, and (c) evaluation of the student's response, reinforcement, and/or branching to another section of the instructional program. Essentially, there are two basic formats in which the tutorial technique is presently being used in CAI lesson design. The first consists of a "complete" tutorial dialogue between the student and the computer. This is to imply that all information, concepts, and learning materials are presented to students via the CAI terminal and no "off-line" media are used. Except in the lower elementary grades this amounts to a tremendous amount of material flowing through the computer and, if exaggerated, the computer has a tendency to develop into an expensive page-turner.

The second form of tutorial lesson is referred to as a "partial" tutorial dialogue in which the student's initial exposure to the material to be learned is from an off-line source such as a lecture, ETV, or book. The material may initially be presented to the student in a more rapid, condensed form which is limited to one-way communication, material to student. The student would then be given diagnostic tests via the computer which would test his understanding of the concepts presented via the initial source and branch him to two-way tutorial routines as previously described.

Drill and Practice

A second basic CAI technique is the utilization of remote terminals for long and tedious drill and practice exercises of concepts to which students have been previously exposed. To date, this technique has been most usefully exploited at the elementary school level. The instructional strategies are usually quite simple; the computer is used to provide practice in learning particular concepts and diagnosing the child's weaknesses. At the end of each day the computer indicates to the teacher which pupils need help, their specific areas of difficulty, and the class standing of each student.

There are basically two types of drill and practice exercises. The first consists of practice problems and routines that are designed by the course author, generated by the instructional program, and presented to the student via the computer terminal.

In the second type of drill and practice exercise the student is allowed to generate his own problem set. Such an exercise provides the student with the opportunity to construct his own problem set and input data, and he responds with his solution to the practice problem. The computer calculates the correct answer and compares it to the student's response. The instructional program may branch the student to additional problems or suggest that the student construct a particular kind of problem or a more difficult one.

Simulation

Computer simulation of laboratory exercises and real world situations represents a third significant CAI technique. The manipulative capability of the computer is put to work in staging complex mathematical models which simulate the occurrence of real world events that might not otherwise have been made available in the instructional process.

Problem Solving

Problem solving involves the utilization of remote computer terminals to perform calculations of various complex formulas or expressions so that the time students devote to routine calculations is reduced. The power of the computer is brought into the classroom in an effort to introduce more complex learning materials.

There are two fundamental modes in which remote terminals can be utilized for problem solving. First, the instructor, in a traditional classroom or laboratory situation, can use the terminal to "demonstrate" the results of changing various parameters of a complex equation. In such a situation only the instructor or a small number of the students actually interact with the terminal, but the results are used to support concepts presented in class.

In the second mode of the problem solving technique, the individual student utilizes the calculational power on a real-time basis in conjunction with CAI materials. For example, if, at a particular point in the design of a CAI lesson, it would be advantageous to have the student himself solve a complex mathematical expression, he can do so without leaving the instructional setting.

Testing

Testing is the fifth basic CAI technique. This technique can be applied either as a stand alone application or, as most often occurs, in combination with one of the other four basic techniques. CAI materials should exploit the computer's ability to present criteria tests, collect student responses, and analyze large volumes of data. There are numerous methods of applying the testing technique to CAI instructional strategies. These include measures of student attainment of specific objectives, diagnostic testing for remedial sequences, curriculum validation criteria, and administrative testing.

CAI in Reference to Other Educational Media Systems

It has generally been said that research efforts to date in CAI have not produced sufficient data to fully evaluate its teaching effectiveness. The state-of-the-art in CAI curriculum development is at the stage where the materials are still being utilized in a test and evaluation mode. Computer assisted instruction is new; it is too early to fully evaluate its total potential and impact upon the instructional process.

There should be no doubt that the computer will have an impact upon the American educational system. The question is "What are the most effective contributions CAI can make to the instructional process?" Several major areas warrant future research in order to fully develop CAI's potential. The design of instructional strategies, complex applications, the role of the teacher, curriculum development cost, and learning theory research are just a few areas that must be studied.

Compared to the other educational media systems studied, CAI has produced less data and information so that it is difficult to establish firm guidelines for its utilization. It is too early in its development to consider CAI as an "operational" educational media system and evaluate it in relation to the other media systems.

SECTION C

EDUCATIONAL ENVIRONMENTS

EDUCATIONAL ENVIRONMENTS

The parameters for each of the educational environments were defined in order to provide a constant basis on which to compare media system costs. The environments are hypothetical; however, they are models which were created after examining actual data. In particular, city and metropolitan area descriptions closely resemble the city of Washington, D. C. and its environs. The geographical areas and population densities are similar to those found in sections of the United States.

Local District Model

The smallest environment is the school district which may vary in size from a few hundred to over a million students. The size chosen for this study was 15,000 elementary and secondary students in an area of approximately 80 square miles. Although the majority of school districts in the United States are much smaller, those with three or four thousand students will not have the distribution problems which become extremely important in larger systems. Also, some of the media systems are too expensive (even in their smallest configuration), and cannot be supported by a small district. However, if these smaller administrative units join together in a cooperative effort, the costs can be apportioned on a per pupil rate for each unit.

The school district used as the model consists of 14 elementary schools and four secondary schools. The elementary schools are a combination of K-6 and K-8 configurations, and the secondary schools include junior, senior, and possibly a vocational high school. For the purpose of this study, an elementary school will have an average of about 600 students; a secondary school will have an average of about 1400 students. The student population in each environment (local, city, state, etc.) has been rounded off to form convenient numbers so that the number of students per school when multiplied by the number of schools will not produce the exact student population indicated.

The school district is irregular in shape. However, all the schools are within a circle whose radius is 6 miles.

The following chart summarizes the data for the local district.

Local District Parameters

Student Population (K - 12)	15,000
Total Population (Approx.)	60,000
Area	80 sq. mi.
Population Density (Average)	750/sq. mi.
Radius of Smallest Encompassing Circle	6 miles
Number of Elementary Schools	14
Number of Secondary Schools	4

City Model

The city covers an area of 70 square miles and has a total population of about 800,000 with approximately 11,500 people per square mile. The shape of the city is roughly rectangular and the entire area can be encompassed by a 6 mile radius circle. There are 150,000 students in 136 elementary and 46 secondary schools. The city can consist of a single school district or a number of school districts which cooperate to gain efficiency and economy through the use of a common media system. The city is not the largest nor most densely populated in the United States. By way of comparison, New York City has approximately nine times the population, four times the area, and more than twice the population density of the city used in this study.

The following chart summarizes the data for the city.

City Parameters

Student Population (K - 12)	150,000
Total Population (Approx.)	800,000
Area	70 sq. mi.
Population Density (Average)	11,500/sq. mi.
Radius of Smallest Encompassing Circle	6 miles
Number of Elementary Schools	136
Number of Secondary Schools	46

Metropolitan Area Model

The population of the metropolitan area is approximately 2 million. Its perimeter has an irregular shape and surrounds an area of approximately 1500 square miles. Because of its irregular shape, a circle with 30 mile radius (2800 sq. mi.) is necessary to completely cover this area.

The area which contains a number of school districts has 546 elementary and 183 secondary schools with a total of 600,000 students (K - 12). It is assumed that these districts would cooperate with one another for some large media projects to achieve economy of operation.

Metropolitan Area Parameters

Student Population (K - 12)	600,000
Total Population (Approx.)	2,000,000
Area	1500 sq. mi.
Population Density (Average)	1400/sq. mi.
Radius of Smallest Encompassing Circle	30 miles
Number of Elementary Schools	546
Number of Secondary Schools	183

State Model

The state has a population of about 4.5 million people. It does not contain a metropolitan area as large nor as populous as described above, though about 60 percent of the population is urban. It has an area of about 40,000 square miles and a population density of about 110 per square mile. Approximately one million students (K - 12) are distributed among 920 elementary and 310 secondary schools.

State Parameters

Student Population (K - 12)	1,000,000
Total Population (Approx.)	4,500,000
Area	40,000 sq. mi.
Population Density (Average)	110/sq. mi.
Number of Elementary Schools	920
Number of Secondary Schools	310

Region Model

The region is approximately a 10 to 1 extrapolation of the state, but a smaller population density is used to bring this figure closer to the national average. The region has an area of 550,000 square miles and a population of about 42 million. There are 10 million students in 9200 elementary and 3100 secondary schools. The region contains a few widely distributed metropolitan areas but no continuous corridor such as found between Boston and Washington.

Region Parameters

Student Population (K - 12)	10,000,000
Total Population (Approx.)	42,000,000
Area	550,000 sq. mi.
Population Density (Average)	110/sq. mi.
Number of Elementary Schools	9200
Number of Secondary Schools	3100

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TITLE
Cost Study of Educational Media Systems and Their Equipment Components

Volume I - Guidelines for Determining Costs of Media Systems

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RETRIEVAL TERMS

Instructional Media
Airborne Television
Broadcast Television
Closed Circuit Televsion
Instructional Television
Video Tape Recordings
Instructional Films
Language Laboratories
Audiovisual Aids
Audiovisual Centers
Radio

IDENTIFIERS
Dial Access
Satellite Television

ABSTRACT

Purpose of this study was to investigate the cost of instructional media systems. Commonly used and proposed media systems were identified and investigated. Information collected provides a data base for use by researchers in further studies relating to the selection, implementation, and operation of media systems. The educator is provided with a set of guidelines for deriving the total cost of planning, implementing, and operating a media system. Cost comparisons are made of several types of systems designed to perform the same hypothetical instructional task. Cost saving recommendations are presented in the areas of educational media system utilization and application of new technology. A supplementary report on computer assisted instruction costs is included.